Teaching senior secondary school mathematics for retention

By

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DECLARATTION

I, the undersigned, declare that by electronically submitting this thesis, the entirety of the work contained therein is my original work, that I'm thereof the sole authorship owner (unless to the extent explicitly otherwise stated), and I have not previously in its entirety or part submitted it for obtaining any qualification.

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ABSTRACT

The very school existence is established on the basis that learners retain, retrieve, or remember what they are taught at a later stage especially during the high-stakes examination at the exit levels and in real-life situations. However, in most cases despite extended instruction periods, often learners *forget* what they were taught. Learners could, therefore, benefit from strategies that produce long-lasting retention, the way to deal with 'the forget problem'. The assumptions are that teachers need to explore retention strategies, use them more, and apply them more effectively; and teachers do not have enough opportunities to improve learner's retention of school mathematics. This thesis intends to confirm these claims. The study emphasis is situated in theoretical and empirical explanations on retention and revision strategies, and various aspects of using and teaching through revision and retention strategies. The methodology part of the study underpinned by the interpretive paradigm depicts the procedure as well as the results obtained from qualitative face-to-face interviews and questionnaires of 10 teachers as well as the classroom observations of eight teachers (four cases from each school). The study also explained and discussed results obtained from the pre-tests, post-tests, and delayed tests for two grade 11 and two grade 12 classes from two different schools. This study was a case study, and the focus group was ten teachers, intentionally and conveniently selected in the Oshikoto region, Namibia. The aims were to explore the teachers' perceptions, experiences, opportunities, and challenges they are faced with in the process of addressing the problem of forgetting. The main research question was: How do Namibian senior secondary school mathematics teachers perceive and experience the facilitation of mathematics through retention and revision strategies? The findings of the study have shown that teachers need more opportunities to explore retention and revision strategies. The results have also revealed that retention and revision strategies have a positive influence on learners' mathematics achievement scores. It is recommended that collaborative professional development programs be designed to stimulate and promote teachers' willingness to develop an understanding of retention and revision strategies and their use.

Keywords: Retention, retention (memorization) strategies, revision strategies, meaningful learning and rote learning.

OPSOMMING

Die hele doel van skoolgaan is dat kinders dit wat daar aan hulle geleer word, sal inneem en onthou. Die suksesvolle terugroep van wat geleer is, is veral belangrik tydens die aflegging van eksamens aan die einde van ‘n skoolfase, maar dit is ook waardevol dat hierdie verworwe kennis uiteindelik in die werklike lewe toegepas kan word. Tog, in die meeste gevalle en ten spyte van verlengde onderrigtydperke, vergeet leerders dikwels die kennis wat hulle opgedoen het. Leerders kan dus grootliks baat vind by die ontwikkeling en aanwending van strategiese vaardighede wat blywende onthouvermoëns verseker en wat die ‘probleem van vergeet’ sal aanspreek. Die aanname bestaan dat onderwysers retensiestrategieë of dan tegnieke om beter te onthou, behoort te ondersoek, dit meer dikwels te gebruik en om hierdie strategieë ook op doeltreffender wyses aan te wend. Voorts kan genoem word dat onderwysers nie voldoende geleenthede kry om leerders se wiskunderetensievaardighede op skoolvlak genoegsaam te ontwikkel en te bevorder nie. Daar is beoog om met die navorsing vir die proefskrif, hierdie aannames te bevestig. Tydens die ondersoek word teoretiese verduidelikings van retensie- en hersieningstrategieë beklemtoon en verskeie aspekte van die gebruik en die onderrig van hersienings- en oproeptegnieke kom onder die loep. Die metodologie vir die ondersoek word ondersteun deur die interpretatiewe paradigma en beeld die prosedure wat gevolg word, sowel as die resultate uit wat bevind is nadat kwalitatiewe, direkte onderhoude gevoer is en vraelyste van tien onderwysers bekom is. Voorts is klaskamerwaarnemings van agt onderwysers (vier gevalle uit elke skool) onderneem. Tydens die ondersoek word gevolgtrekkings verduidelik en die bevindinge wat spruit uit die vooraftoetsing, natoetse asook die uitsteltoetsing van twee graad 11- en twee graad 12-klasse van twee verskillende skole, word bespreek. Die ondersoek neem die vorm van ‘n gevallestudie aan en die fokusgroep bestaan uit tien onderwysers, doelbewus gekies uit die Oshikoto-streek in Namibië. Die doel van die studie is om onderwyserervarings te ondersoek en om die geleenthede en die uitdagings tydens die aanspreek van die sogenaamde vergeetprobleem, te verken. Die hoofnavorsingsvraag is: Hoe word retensie- en hersieningstrategieë deur Namibiese senior sekondêre onderwysers in hulle onderrig van skoolwiskunde gebruik? Die bevindinge van die studie dui daarop dat onderwysers meer geleenthede gegun behoort te word om retensie- en hersieningstrategieë te verken. Die resultate wys ook daarop dat die toepassing van retensie- en hersieningstrategieë ‘n positiewe invloed op leerders se prestasievlakke in wiskunde uitoefen.

Sleutelwoorde: Retensie (terugroep), retensiestrategieë (memorisering), hersieningstrategieë, betekenisvolle leer en papegaaiwerk.

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CHAPTER 1

BACKGROUND AND ORIENTATION OF THE STUDY

1.1 INTRODUCTION

This study was seeking to explore the problem of ‘forgetting’ in school mathematics. The purpose of the study was to explore the perceptions and experiences of senior secondary school teachers’ mathematics facilitation through retention strategies. This chapter narrates the context and motivation for the study and strives to demonstrate the significance of the study with regards to school mathematics teaching. The chapter also discusses the research aims, objectives and research questions. An outline of the design and the methodology used in this study is also summarised in this chapter. The chapters of the study are briefly outlined at the end of the chapter.

At a broad policy level, poor performance in the national senior secondary school mathematics examinations is ongoing. Other than that, there is an emerging implementation of a new Namibian revised curriculum, for the Namibia Senior Secondary Certificate Ordinary level (NSSCO, 2015), the Namibia Senior Secondary Certificate Higher level (NSSCH, 2015) and an Advanced Secondary level (AS, 2015) since January 2015. The Namibian mathematics curriculum which previously comprised of grades/phases from Grade 1 to Grade 12 now consists of grades/phases from Grade 1 to Grade 13 (The Republic of Namibia National Implementation of the Revised Curriculum for Basic Education, 2014). The advancement of the curriculum is a form of basic education guidance towards achieving Namibia Vision 2030. For example, during the year 2018, the Grade 9 learners were learning the previously grade 10 learning content. In the year 2019, Grade 10 learners will be learning the content previously known at the Grade 11 level.

The revised curriculum is being implemented as follows; the **Junior Primary Phase** (Grades 1-3) implemented in 2015 and the **Senior Primary Phase** (Grades 4-7) implemented in 2016 (The Republic of Namibia National Implementation of the Revised Curriculum for Basic Education, 2014). For the **Junior Secondary Phase** (Grades 8-9), Grade 8 was implemented in 2017 and Grade 9 in 2018 (The Republic of Namibia Implementation of the Revised Curriculum for Basic Education, 2014).

For the **Senior Secondary Phase** (Grades 10-12), Grade 10 will be implemented in 2019, Grade 11 in 2020 and Grade 12 in 2021 (The Republic of Namibia Implementation of the Revised Curriculum for Basic Education, 2014). A new Cambridge International Advanced Level will be introduced in the Namibian Secondary Education curriculum in the year 2022. It is planned that Grade 13 will be implemented in 2022 (Republic of Namibia National Implementation of The Revised Curriculum for Basic Education, 2014). As a result of the revised curriculum, the learning content level of every grade has also scaled up.

The reality of school mathematics is that learners are regularly tested throughout the school years. Many mathematics courses in the different grade levels and especially those at the exit level conclude with high-stakes examinations and have major consequences of passing or failing a grade. Similar consequences can be found at other tertiary institutions. In such situations, learners are required to retain information from a whole year of learning or more years.

According to research, human beings forget approximately 50% of newly learned information in a matter of weeks or days (Averell & Heathcote, 2010; Ebbinghaus, 1885; Murre & Dros, 2015; Rubin & Wenzel, 1996;), cited in Julie (2013:322). School acquired knowledge can be forgotten within days or weeks (Rohrer & Taylor, 2006). People forget ‘a lot’ of what they learn (Rohrer & Pashler, 2007). Rohrer, Taylor and Pashler (2006), who did studies on strategies that could promote long-lasting retention, state that as soon as the learnt material is forgotten, the benefit of studying or learning is lost (Rohrer & Taylor, 2006). Forgetting is one of the leading causes of poor performance and low achievement in mathematics (Julie, 2011). Non-retention of knowledge and skills has been identified as one of the major contributing factors to low achievement in tests as well as examinations. Students could benefit from strategies that produce long-lasting retention (Rohrer & Pashler, 2007 & Julie, 2011). Learners forget during the school years and during high-stakes examinations. It is normal that learners forget mathematics content. For this reason, it is critical to know special learning strategies that advance long-lasting retention.

According to the researcher, some special strategies then need to be in place. From my time as a school teacher, I have learned that teachers use different memorization/retention and revision strategies in teaching English grammar, geography, physics, and other subjects because learners forget information. Some of the major mechanisms could be retention and revision strategies. These would aid teachers to extend the extent of the learners’ opportunities for learning mathematics. These would also allow the teachers to teach in a way that would reward learners’ personal understanding and speedy assimilation, as well as retention, thus enhancing learners’ mathematics achievement. This is to allow learners to fully take in or absorb and understand information and respond to unfamiliar situations in adherence with existing knowledge (Rohrer & Pashler, 2007).

1.2 MOTIVATION FOR THE STUDY

This study was prompted by various factors, largely the researcher's individual experiences as a senior secondary school mathematics teacher. In the year 2012, the Ministry of Education introduced mathematics as a compulsory school subject from Primary to Senior Secondary Education (The Republic of Namibia National Mathematics Subject Policy Guide, 2009). This was done because Mathematics was recognised to be very essential to everyday life (The Republic of Namibia National Mathematics Subject Policy Guide, 2009). While mathematics is a compulsory school subject, moreover, there is an emergence of a new Namibian revised curriculum implementation as described in the previous section. The main concern is that statistics show that performance in the Namibian National Senior Secondary School (grades 11 & 12) examinations is very poor in mathematics every year (Himarwa, 2017).

The researcher believes that learners' achievement in tests or examinations is controlled by their ability to recall and retrieve what they have been taught or learned in the classroom. The key factor in learners' recalling and thus improved achievement is retention. It appears as if Namibian teachers are experiencing challenges in communicating mathematics to the learners in a much more explicit manner that would enable learners to retain and remember what they are taught. Because people forget a great deal of what they learn, learners could benefit from learning techniques or strategies that produce long-lasting retention (Rohrer & Pashler, 2007). Research indicates that in school mathematics, these strategies have to do with the nature and kinds of 'revisions' that are given to the learners as a way of dealing with forgetting. The researcher, therefore, desired to explore the perceptions as well as the experiences, retention and revision strategies that are used by senior secondary school mathematics teachers in Namibia. The research focused on senior secondary school mathematics teachers in the Oshikoto region, Namibia. Meeting with these teachers was convenient for the researcher as the two participant schools where in close vicinity to where the researcher's duty station is.

1.2.1 Aim of the study

The main aim of this study was to investigate the pedagogical experiences of the Grades 11/12 teachers from two schools in the Oshikoto educational region of Namibia regarding their understanding and facilitation of mathematics through retention and revision strategies. The study helped the researcher as a senior secondary school mathematics teacher to gain additional insight into the school mathematics learning through retention strategies. The insight acquired may help advance the learning and teaching of school mathematics in Namibia in the future.

1.2.2 Significance of the study

It is anticipated that the outcomes of the study may have implications for collaboration by educators and teachers in Namibia to work together with fellow teachers or employees of the Directorate of Education offices to design learning materials and work on projects that can help with revision and retention. There is currently a ‘similar’ Erongo region-based annual development project running in Namibia known as the National Mathematics Congress (NMC), but this project combines primary to secondary mathematics teachers, moreover, it has not looked in particular at retention and revision strategies. Therefore, the results of the study may build on the improvement of senior secondary school mathematics teachers’ teaching skills through retention and revision strategies. Moreover, the study might be useful to respective Namibian education policy makers especially with regard to staffing norms, teacher to learner ratio as well as the subjects/periods and teaching time allocations in schools. These are some of the factors found to contribute to the challenges facing teachers in the process of addressing the ‘forget problem’. Education policy makers are responsible for any amendments regarding these issues.

1.3 PROBLEM STATEMENT

The researcher is concerned with ‘memory’ and ‘forgetting’ in the learning of high school mathematics. Thus, this research’s emphasis is situated in the literature on ‘retention,’ which in school mathematics relates to the kinds and nature of memorisation and revision strategies that are given to learners as a way to deal with the problem of forgetting. Learners in grades 11 and 12 have a problem recalling mathematics content when it comes to high-stakes or other types of examinations or tests, as well as in ordinary classroom teaching situations. This ‘forget problem’ is a concern that many teachers face in their teaching. This study, therefore, explored how grade 11 and 12 mathematics teachers in Namibia perceive and experience retention and revision strategies.

The researcher had the opportunity to observe teachers teaching mathematics in their own classrooms for almost two months during the months of September and October 2019. This was an important time in terms of the academic year with its many tests and assessments. This period also, therefore, coincided with the researcher’s research or data availability. This period was thus an opportune ‘window’ to see how and why teachers were concerned with ‘forget’ issues. The academic of school year timing met the demands of my research so well.

The researcher interviewed, observed the teachers as they used different retention and revision strategies and asked the teachers to complete a number of questionnaires. The study also investigated whether teachers are maintaining a fair interplay between retention and revision strategies during their own classroom teaching.

The main premise was that, should the teachers use experimental and effective retention and revision strategies, there should be an improvement in the manner in which mathematics is taught and learned and eventually better results in mathematics assessment. The other premise was that there might be an enhancement in the retention of the learners who were exposed to more explicit retention strategies in comparison to those who were not.

It is universally known that mathematics can play a significant role in forming how an individual learner or adult deals with different domains of private, social and civil life (Walshaw & Anthony, 2009:147). However, at the period of this study, as stated earlier, many of the grade11-12 learners in Namibia do not perform well in mathematics, in spite of the fact that great grade 12 results in mathematics pave ways to scarce careers in, for instance, medicine, engineering, astronomy, and biotechnology.

The Grade 10 Junior Secondary Certificate (JSC) national performance in mathematics for the year 2017 was 52.1 % (Himarwa, 2017). The Grade 12 NSSC overall performance in the year 2017 could not meet the targets set as per the Republic of Namibia National Development Plan (NDP 5) for learners scoring a D symbol or better (Himarwa, 2017). The Grade 12 NSSC achieved 41.7 % in mathematics, below the national target of 47% (Kambowe, 2018). The Ministry of Education Arts and Culture aligned its 2018 Republic of Namibia Strategic Plan to the fifth National Development Plan (NDP 5) so that by the year 2022, the learners' NSSCO performance improves by 20% in Mathematics (The Republic of Namibia Strategic Plan, 2018).

Currently, the intended Namibian secondary mathematics curriculum is applicable to three levels for the national examination. The three levels from the highest to the lowest level are the National Senior Secondary Certificate Higher level (NSSCH), the National Senior Secondary Certificate Ordinary level (NSSCO) Extended level, and the National Senior Secondary Certificate Ordinary level (NSSCO) Core level.

From the year 2011 to 2017, the examination enrolment for all levels showed that more learners enrolled on NSSCO (Core), fewer learners on (NSSCO) Extended and even lesser on NSSCH (Ndjendja, 2018). For the past 23 years, 12 % or less of the mathematics candidates register their mathematics on an extended level (Ndjemdja, 2018). This means that only a percentage of 12 or less of the candidature have a chance to obtain a B or A grade. This means that the majority of the candidature who qualify to access the University of Namibia (UNAM) for any teaching qualification in mathematics have only done Core and it is against this background that the newly revised curriculum is designed in a way that it will be examined at one level only and there will be no more core and extended levels (Ndjendja, 2018).

As mathematics is one of the subjects most adult learners in Namibia find challenging, these results are a product of the 'forget problem'. Based on the results above, therefore, the researcher believes that there could be a problem in the mathematical instructional process, and studying retention strategies could improve teachers' mathematics teaching abilities and skills. This could form part of the solution.

The researcher, therefore, wanted to study the Namibian senior secondary school mathematics teachers' perceptions and experiences with incorporating retention and revision strategies in their teaching. The researcher suggests that teachers need to explore more of these strategies and use strategies that promote meaningful learning and thus performance and academic achievement. It is against this background that this qualitative study on Grades 11-12 teachers with a special focus on retention was planned.

1.4. RESEARCH QUESTIONS

In order to understand the goal of this research, the research questions below informed and directed this study:

1.4.1. The main research question

The main research question for this study is:

How do Namibian senior secondary school mathematics teachers perceive and experience the facilitation of mathematics through retention and revision strategies?

1.4 .2. Sub-research questions

The sub-questions below were addressed:

1. What do we know about effective teaching retention and revision strategies that can improve learners' retention in senior secondary school mathematics classrooms?

2. What are and why teach retention strategies in senior secondary school mathematics?

3. Are there differences between retention and revision strategies or are they the same?

4. What is the relationship between revision and retention strategies?

5. What is rote learning and why does it take place?

6. How do Namibian senior secondary school mathematics teachers use retention and revision strategies in their teaching?

7. Do retention and revision strategies work or not?

8. What are the challenges experienced by senior secondary school Namibian mathematics teachers in the process of addressing the ‘forget problem’?

9. How can learners’ retention be improved?

10. What are the ways of studying the retention/revision strategies of the teachers?

The sub-questions aided the researcher to gather rich data. These sub-questions guide the literature review of this study.

1.5 RESEARCH AIM

The main aim of this study was to investigate or explore the experiences of senior secondary mathematics teachers of two schools from the Oshikoto educational region of Namibia concerning teaching school mathematics through different retention and revision strategies.

1.6 RESEARCH OBJECTIVES

Research objectives are clear and brief declaratory explanations that guide towards the investigation of variables (Fatima, 2016:3). They are simply an illustration of what is to be accomplished by the study (Fatima, 2016:3). According to Wanjohi (2014: 12), research objectives are obtained or derived from the aim or purpose of the study and they point out what the researchers intend to achieve. The developed objectives are stated below:

- To determine the perspectives of senior secondary school mathematics teachers on their teaching through retention strategies.
- To observe how the Namibian senior secondary school mathematics teachers use/apply retention/revision strategies in their mathematics classrooms.
- To investigate whether there was an improvement in the retention of the learners through pre- and post-evaluation.
- To observe and discover the opportunities and challenges experienced by the Grades 11 and 12 teachers in addressing the ‘forget problem’.

- To conduct research that might inform and contribute to how the Namibian senior secondary mathematics teachers use different retention strategies and overcome possible challenges.
- It is hoped that the outcomes of this study will have implications for collaboration work for educators or teachers in Namibia to work together with fellow teachers or staff from the directive offices to design learning materials and work on projects that can help with revision and retention.

1.7 RESEARCH DESIGN AND METHODOLOGY

This section represents an account of the structure and the methods of the study. It constitutes a summary of an explanation of the design and methodology of the research study, which follows in the third chapter. Due to the epistemological stance of this study (since this is an exploratory research), a qualitative research approach was adopted.

An interpretive qualitative paradigm underpinned this study. The researcher wanted to make sense of the data collected through different data collection tools. The researcher wanted to explore, make sense of and understand the senior secondary school mathematics teachers' perceptions and the use of retention strategies in their classrooms. The core significance of this paradigm is that it allows the researcher to comprehend participant teachers' perspectives and make sense of them (Aryl et al., 2006:462). A research design describes the framework that informs and guides all the tasks and procedures of research. A multiple-case design was found to be a suitable genre or approach suitable for this research study. A multiple-case study is needed when a study comprises two or more cases (Yin, 1993:5). The researcher is studying several cases to understand the similarities and differences between the different cases (Baxter & Jack, 2008; Stake, 1995, cited in Gustafsson, 2017:3). The researcher chose ten teachers as particular cases operating from within real-life contexts; in this case, the school is the context in which the researcher describes and evaluates their learning and teaching experiences as senior secondary school mathematics teachers.

A case study is a research procedure and experimental investigation that intensively studies a phenomenon within its actual contexts. It's an exploratory and explanatory analysis of a person, event or group (Yin, 2009:41). Multiple case studies are either used to predict different results for anticipated reasons or predict similar findings for the research study (Yin, 2003, cited in Gustafsson, 2017:3). In this way, the researcher can verify whether the research outcomes are relevant or not (Eisenhardt, 1991, cited in Gustafsson, 2017:3). Evidence generated from multiple case studies are considered powerful and reliable (Baxter & Jack, 2008, cited in Gustafsson, 2017:3).

An additional advantage of multiple case studies is that they produce more convincing theories when ideas are heavily grounded in practical evidence (Gustafsson 2017:3). A grounded theory qualitative research approach/design was therefore used as a way in which the data was collected and analyzed from this case study ('grounded' meaning that the analysis is rooted in or based on what teachers say and do). These are then 'theorised' as a way to 'ground' and to build theory or abstractions of what the teachers say and do when they talk about and share their revision and retention strategies. This design is used to generate a theory found in the data at a broad theoretical level (Creswell, 2012:423). A grounded theory was introduced by Glaser and Strauss who thought that theory could surface or emerge out of qualitative data analysis (Strauss & Corbin, 1990).

Although this research was largely qualitative, a convergent design was also used to merge the pre- and post-test results (quantitative data) and qualitative data. A convergent design is one of the types of mixed methods research whereby the researcher collects both qualitative and quantitative data to analyse both sets of data and merge results. Mixed methods research is an approach to research where an investigator collects and integrates both qualitative and quantitative data and uses the combined strengths of both sets of data to elicit or draw interpretations (Cresswell, 2015:2). The purpose was to get a deeper insight into the problem that had both quantitative and qualitative dimensions. This helps with acquiring a more thorough view of a problem that would not be allowed by either a quantitative or qualitative study alone. A thematic analysis of qualitative data and statistical analysis of quantitative data are employed (Cresswell, 2015:2).

1.7.1 Data generation

Research data are 'pieces of information found at a site' that are gathered logically to provide evidence from which statements and clarifications intended to enhance knowledge and understanding regarding a research question or problem are established (Lankshear & Knobel, 2005:172). The data generated in this study related to how Namibian senior secondary school mathematics teachers perceive and experience the facilitation of mathematics through retention and revision strategies at two high schools in Oshikoto region. However, for qualitative researchers, data should not be regarded as that which is there to pick up but comparatively what the researcher can produce and record (David & Sutton, 2004:27). The researcher decides what is to be considered as data based on the questions that guide the study. Data generation methods used to collect data in this study incorporated qualitative semi-structured interviews, researcher's class observations (field notes), and unstructured/open-ended and semi-structured questionnaires, which were developed and facilitated by the researcher.

1.7.1.1 Selection of participants

To select research participants, selection procedures are required. It is possible that all teachers will have several intuitive and professional understanding and strategies but it is not likely for all of them to be the same neither equally explicit. Some learners are more likely to be exposed to more explicit strategies compared to others. The total number of participants is 10 school mathematics teachers from two senior secondary schools. The researcher purposefully sampled only four teachers from each of the two schools for observations. However, all 10 teachers participated in the interviews and completed all the questionnaires. Permission from Stellenbosch University, Namibian Ministry of Education, Arts and Culture and school principals was obtained (please see appendices 1, 2 and 3). Written letters of consent were obtained from the teachers and learners. Confidentiality, anonymity, and use of pseudonyms were taken into consideration.

Eight teachers, who participated in classroom observations were chosen, based on their responses to the interviews and the number of years of experience. Furthermore, all the teachers were selected based on their interest in the research topic and the willingness of the teachers to participate in the study, to share their experiences and for personal professional growth. The eight selected teachers were therefore considered to be more likely to help the researcher to gather rich data for the study, as they seemed more informed and the researcher needed varied years of teaching experience. The selection of the two schools was based on the convenience of the researcher concerning the researcher's research budget and proximity.

1.7.1.2 Semi-structured face-to-face interviews (See appendix 6)

Semi-structured face-to-face interviews were used to generate data on retention and revision strategies for senior secondary school mathematics. Ten senior secondary school mathematics teachers from two schools in the Oshikoto region were used to generate data. This was done to support or supplement data collected through questionnaires and classroom observations. The researcher made use of an interview timetable and an electronic device with the 10 teachers in order to produce data regarding the facilitation of school mathematics using retention and revision strategies.

Participants were given a platform to ask questions and get clarity on the questions that they were asked and the researcher was able to comment on the participants' contributions. The teachers were interviewed during their free periods. The researcher took notes and recorded their responses. The teachers were interviewed at their schools, during their free periods, after the necessary arrangements were done by the researcher through the school principals. A total number of ten teachers from the Oshikoto region in the Oshivelo circuit were interviewed, and they were six teachers and four teachers from each school respectively. The interviews, which dealt with a brief overview of the teachers with regards to their background, ideas and experiences on facilitation of mathematics through retention and revision strategies, assisted the researcher in selecting the teachers who were observed.

1.7.1.3 Classroom Observations (See appendix 7)

The researcher completed observation sheets while observing the teachers teaching in their classrooms. The observation sheets contained the possible retention and revision strategies that can be used by grade 11 and 12 teachers. The researcher then determined which and how the teachers used some of these strategies. To supplement the observation sheets, the researcher took some notes as well during the classroom visits.

During observations, teachers who were observed to be applying more explicit revision and retention strategies were intentionally and purposefully identified. The researcher then shared some retention and revision strategies that she finds most productive based on the reviewed literature, with the teachers who showed more explicit retention and revision strategies, who then applied the strategies with their learners. This was done with one teacher from each pair and it was necessary for the researcher as a control. Pre- and post-tests were set, observed, marked and recorded by the researcher. A total number of four teachers were observed for each school.

1.7.1.4 Questionnaires (See appendix 8)

Data was also generated using two unstructured and semi-structured questionnaires. From these, data analysis, description, and interpretation were done. The researcher used open-ended questionnaires as this was more of an exploratory study, to acquire narrative data. Only four multiple-choice questions were used at the beginning of the semi-structured questionnaire. All ten senior secondary school mathematics teachers completed the questionnaires.

1.7.2. Data analysis.

From the data collection techniques applied in the study, data were analysed using the qualitative content analysis through a cautious examination of data and constant comparison. The researcher integrated the theoretical sampling process and the constant comparative method to develop grounded theory. After identifying, comparing, and categorising units and producing themes, themes and emerging sub-themes produced were coded. The investigator coded the data by carefully reading and examining transcribed data as well as the data obtained from questionnaires and observations very carefully while categorizing them into relevant units using unique identifying names or descriptive words. These categories were put to further analysis by finding relations and interrelations among them. Simplification of data was then done through data reduction and short summaries and conclusions which consist of new findings were done. The researcher employed statistical data analysis of the quantitative data analysis to analyse numerical data from the pre- and post-tests.

Even though the writing was at times distractive, data was recorded through writing during face-to-face interviews and class observations. A digital voice recorder was used to record the interviews. The voice recorder was however only used as a back-up instrument and not to analyse data directly from it. An observation sheet was used during classroom observations to record which of the different retention and revision strategies was used and how they were used by the respective teachers, to give a picture of what transpired in their classrooms. The use of all the data recording mechanisms and instruments were agreed upon by all the participants.

1.7.3. Delineations and limitations

The researcher focused on teaching senior secondary (grades 11 and 12) school mathematics through revision and retention strategies. The researcher concentrated on a single aspect of school mathematics teaching to make sure that the study was manageable. The study was restricted to two senior secondary schools in one education region in Namibia. This study was limited to ten senior secondary school mathematics teachers. The results of this study may therefore not be necessarily generalized beyond its confines.

1.7.4. Assumptions

All teachers will have an individual number of retention and revision strategies acquired through teaching experiences or education. This study was established on four assumptions:

- The participant teachers possess some intuitive know-how about retention and revision strategies even if they don’t know their special mathematical terms.
- Teachers might have the ability to apply a large number of retention and revision strategies in their mathematics classrooms but such opportunities are restricted by certain challenges.

- Teachers don’t have opportunities to deepen their thinking on mathematics and there could be time restrictions.
- All teachers can be provided with opportunities to improve learner’s retention of school mathematics.

1.7.5. Trustworthiness and credibility

Multiple data-collection sources such as semi-structured interviews, observations and questionnaires were used to prevent distortion or one-sidedness that may result from limited use of one data-collection method. Multi-method techniques such as interviews, questionnaires, and observation advance the credibility and validity of this qualitative research (McMillan & Schumacher, 2001:429). According to Stenkie (2004:184), misrepresentation and uneven-handedness that may develop from specific methods can also be taken care of.

1.8 ETHICAL CONSIDERATIONS

The researcher obtained permission from the Directorate of Education, the Oshikoto region, for the study comprised of learners and teachers of the particular region. The study required interviewing and observing the teachers in their classrooms as well as piloting and completion of questionnaires by the teachers. The study also involved observing learners, and accessing learners’ assessments for the purpose of research. Thus, permission was also obtained from the school gatekeepers in order to gain access to the prospective participants. The parents’ consent and learners’ assents were obtained in order to access their assessment marks and to analyse their assessments as part of the research data (see Appendices 4 and 5).

The teachers were briefed that their participation was important and voluntary and that they were at liberty to withdraw at any stage or opt out from answering particular questionnaire questions, without any penalties. Pseudonyms were used to conceal the identities of teachers for the purpose of confidentiality and anonymity. The ethical clearance application process was completed by the researcher and all ethical matters were clarified and approved by Stellenbosch University Research Ethics Committee, Human and Social Sciences.

1.9 THESIS OUTLINE

Chapter 1 provides the background and orientation of the study. In chapter 2, the literature relevant to the research question is reviewed and explored by establishing several theoretical aspects. Chapter 3 presents a description of the design and methodology of the research employed in describing, analysing and interpreting the experiences of senior secondary school mathematics teachers facilitating retention and revision strategies. Chapter 4 comprises research empirical findings presentation, analysis, and interpretation. Chapter 5 concludes the research findings, knowledge practice implications, recommendations and reflections on the research process.

CHAPTER 2

A THEORETICAL PERSPECTIVES

2.1 INTRODUCTION

How do Namibian senior secondary school mathematics teachers perceive and experience the facilitation of mathematics through retention and revision strategies?

This study builds on existing literature. The study takes a topic from the literature but addresses it from a different perspective. My study addresses a gap in knowledge, breaks new ground, and illuminates the topic in a new way. Many studies have looked at retention and/or revision with a special focus on very few particular strategies. Contrarily, this study is a diversified collection of retention and revision strategies, comparing the past and current efforts to address the forget question. The theoretical framework has been used in this study because it has been used in similar studies. The concepts shed more light on the topic and helped the researcher to understand the study in a useful way. The theories assisted the researcher to analyse and interpret data in illuminating ways. A more thorough analysis of the above research question will follow.

The focus in this chapter is on five aspects of this research study, which contributed to producing a theoretical perspective of this study. The first part will be a review of the literature on retention and revision strategies, and their roles in senior secondary school mathematics, adapted mainly from 'meaningful learning' theory. The second section reviews the distinction, relationships, and interrelationships between the multiple retention strategies. In the third part, senior secondary school mathematics education relating to facilitating and learning through retention strategies will be discussed. The fourth part explores what rote learning is and why it takes place. The fifth part reviews an aspect of school mathematics teaching and the use of various revision and retention strategies by Namibian senior secondary school mathematics teachers. The sixth part focuses on the challenges experienced by senior secondary school mathematics teachers in the process of addressing the 'forget problem' whilst the seventh section focuses on how learners' retention can be improved.

One of the main aims of the intended senior secondary mathematics curriculum is the development of learners' insight into and ability in using mathematics-related notations and symbols to describe and reason about variables, expressions, equations, inequalities and functions (Fey & Marcus, 2006:59). However, in most cases, despite the period of practice and instruction, learners often struggle to master and apply basic school mathematics algorithms accurately in many mathematical situations. Learners *forget* what they learn. The very existence of schools is based on the belief that learners learn something from what they are taught and remember some of these things in the future (Elis & Semb, 1994).

Generally, the most crucial aim of teaching any school subject is for the learners to make sense of, remember and use the acquired knowledge of the subject in real life. Unfortunately, the experiences with a lot of mathematics topics, for many learners, are meaningless and represent nothing real or useful to real life and most of all, they *forget*. These pointless experiences could be an outcome of the type of teaching experience in the learning of senior secondary school mathematics (Gurouws, 2006:129). Various studies argue that the past attempts to improve mathematics education are grounded in a popular traditional paradigm and, therefore, advocate for a culture of learning and belief that all learners can and should learn meaningful mathematics (e.g. Berry III & Ellis, 2005:7; Hoque, 2019:1; Julie, 2011; Julie, 2013; Julie, 2019; Mayor, 2002:226). It is believed that reforms grounded in or established on this new paradigm ('meaningful learning'), can finally transform and improve the way how learners experience achievement in school mathematics. Therefore, the researcher suggests that meaningful learning is a precondition for 'retention' and thus success in school Mathematics.

The new paradigm of meaningful learning emerged because learning by insight is known for advancing the learners' ability to recall better. Furthermore, meaningful or insightful learning was observed and recognised for boosting the learners' ability to make connections between new mathematical problems and previously learned mathematical knowledge. Thus, the learners' retention of information is advanced to a point where they don't only recall information as a theory but also apply what they learn to everyday practical problems and hence real-life situations. By making connections, they would be able to match, connect learned content and produce possible solutions to new kinds of problems that may crop up in any type of examinations and mathematics tasks of any kind or when they do homework. Doing countless procedural knowledge-based exercises leads only to short-term achievement. Ordinarily, skills gained through understanding not only are hardly forgotten but also means students bring knowledge towards new practice problems (Kindt, 2011:138).

With meaningful learning, the effort to upgrade mathematics education has focused mainly on how the subject matter is taught, with little attention paid to the role or the aspect of the number of practice problems (Rohler & Tylor, 2007:481). Yet a lot of teachers devote the majority of their mathematics teaching to practice problems (problems of practice). Practice problems are usually exercises that test learners' abilities to directly apply essential concepts of previously learned content. Successful mathematics teaching and learning depend on the effective usage of appropriate classroom settings and teaching procedures (Githuwa & Nyambwa, 2008). All these views are consistent with that of Bah et al. (2019:93) who state that failure to master something is not determined by cognitive abilities alone, but rather by the choice of cognitive strategies or techniques.

When studying an instructional process, the point of interest is usually the focus of practice and how it is achieved (Steve et al., 2003:19). In physical education, for example, it is motor skills development; instructors are always trying to find more effective strategies of teaching their students motor skills to improve learning, achievement, and retention (Steve et al., 2003:19). In physical education, the two most important strategies are massed and distributed practice (Steve et al., 2003:19). In this study, in the case of mathematics, the focus of practice is retention and the retention (memorization) and revision strategies, as the main constituents of meaningful learning which are the ways through which the 'retention' of school mathematics education can be achieved.

In school mathematics education, 'forgetting' has been a concern that many teachers face in their teaching and the fundamental problem underpinning this study. For this reason, several researchers have always been trying to find effective methods that could address the 'forget problem'. Several studies have been carried out to bring about long-lasting retention and thus meaningful learning. One reason why students may have poor memory is inappropriate support in terms of retention and revision strategies (Bah et al., 2019:93). The path to achieving meaningful school mathematics learning and thus long-term retention is an integration of memorisation (retention) and revision strategies (Mayor, 2002:226).

2.2 MEANINGFUL LEARNING

Meaningful learning is based on the two most important educational goals of the Taxonomy of Educational Objectives of '*retention*' and '*transfer*' (Mayer, 2002:226). Therefore, 'retention' and 'transfer' form meaningful learning. Meaningful learning happens on a continuum, based on the quality and quantity of relevant ideas acquired by a learner and the extent of his/her effort to relate new knowledge to relevant prior knowledge (Novak, 2002:552). The researcher finds these objectives an expression of an idea that a learner should not only remember but should *remember* and *apply*. Meaningful learning is known as an important goal of education (Mayer, 2002:227). Meaningful learning is a viewpoint of learning as the building of knowledge where learners pursue not only to remember things directly as presented but to make sense of their knowledge (Mayer, 2002:227). Meaningful learning takes place when learners construct knowledge and cognitive processes required for successful problem-solving (Mayer, 2002:227). Problem-solving entails coming up with ways of attaining a goal that one has never achieved before or figuring out ways to change a given situation into a new one (Mayer, 2002:227). The goal of meaningful learning is a deep understanding of a subject matter.

Meaningful learning became eminent in mathematics and science education in the 1960s through the efforts of David Ausubel, an educational psychologist who developed the theory of 'meaningful learning' to label learning that is a total opposite of rote learning (Gunston, 2015: 226). The theory suggests that meaningful learning, which means learning by 'deep understanding', is good, and rote learning, which means leaning with 'little understanding', is bad (Gunston, 2015:226). Meaningful learning has become so widespread that it serves as a designation for learning that is found worthwhile, of absolute purpose and in a broad range of contexts (Gunston, 2015:226). Ausubel's view of meaningful learning is that learners must connect new knowledge (propositions and concepts) to existing knowledge (Novak, 2002: 550). The table below illustrates Ausubel's advanced theory which contrasts meaningful learning with rote learning.

Type of Learning	**Characteristics**
Rote Learning	**Meaningful Learning**
Verbatim, arbitrary, non-substantive affiliation of new ideas into the cognitive structure.	Non-verbatim, non-arbitrary, substantive, affiliation of new knowledge into the cognitive structure.
No intention to relate new ideas with existing knowledge in cognitive structure.	Intentional effort to connect new knowledge with higher-order ideas in cognitive structure.
Learning not linked to experience with objects or events.	Learning integrated and connected to experience with objects or events.
No intuitive engagement to link prior knowledge to new ideas.	Intuitive responsibility to connect new ideas to prior learning.

Figure 2.1 Rote learning contrasted with meaningful learning

(*Source*: Adapted from Novak, 2002:549-552)

The goal of meaningful learning is to develop a broader view of learning that contains a complete range of cognitive demands or levels (Mayer, 2002:232). The goal is to explore how instruction and assessment can be extended beyond a limited focus on the cognitive level of '*Remember*' (Mayer, 2002: 232). The revised Taxonomy of Educational Objection consists of a total number of 19 different cognitive processes linked with six process categories. The two categories are associated with one main category of '*Remember*' while the other 17 categories are related to the five main cognitive process categories of *Understand*, *Apply*, *Analyse*, *Evaluate* and *Create* (Mayer, 2002:232).

The two cognitive processes related to '*Remember*' are *recalling* and *recognizing.* The 17 categories associated with the other five categories are *interpreting*, *classifying*, *summarizing*, *exemplifying*, *comparing*, *inferring*, and *explaining* which are related to 'Understand'. Two categories are associated with *'*Apply*'*: *executing* and *implementing*. *Attributing*, *differentiating* and *organizing* are related to 'Analyse'. *Checking* and *critiquing* are associated with 'Evaluate'. The three associated processes categories for 'Create' are *producing*, *planning* and *generating*. These sums up the revised Taxonomy to 19 cognitive processes related to six process categories.

On the teaching part, the two cognitive processes aid to promote '*retention*' whereas the 17 help promote '*transfer*' (Mayer, 2002:232). On the side of the assessment, the cognitive process analysis is to assist educators inclusive of test designers and teachers to widen the manner in which learning is assessed. When the goal of teaching is to improve transfer, assessment activities should include cognitive procedures that go beyond identifying and recalling (Mayer, 2002:232). Admitting that assessment activities that deal with these two cognitive procedures possess a part in the assessment, these activities can, and regularly should be strengthened with those that use the complete range of cognitive procedures needed for the transfer of knowledge (Mayer, 2002:232). The point here is an indication to the teachers that both assessment tasks using cognitive processes that promote remembering and transfer have a place in the assessment.

The need to shift from rote learning, that is learning with 'little understanding,' and focus on meaningful or insightful learning, which means learning by 'deep understanding', resulted in the emergence of several retention and revision strategies, which we review next. Understanding anything can be 'rote or 'deep'. A grade 12 learner can have only a rote understanding on mathematics and still obtain a good mark or higher symbol. Therefore, it is important that all cognitive levels are covered in the Namibian policy documents.

2.3 RETENTION AND REVISION STRATEGIES AND THEIR ROLES IN SENIOR SECONDARY SCHOOL MATHEMATICS

The section below will begin with an introduction. This section will then establish a description of different retention and revision strategies recommended by other researchers starting with retention strategies which are also called memorization strategies.

Learning requires acquisition of knowledge (Mayer, 2002:226). There are three outcomes of learning and they are; 'no learning', 'rote learning' and 'meaningful learning'. 'No learning' is self-explanatory. 'No learning' means a person can remember very little that she/he learnt, neither possesses nor is able to use the related knowledge (Mayer, 2002:226). 'Rote' and 'meaningful' learning are some of the integral notions of this study that are interpreted in this chapter.

Thinking of the acquisitioning, prospective teachers often stress the type of cognitive processing (remembering) in teaching and assessment (Mayer, 2002:226). Bloom's Taxonomy objectives seek to produce meaningful learning (Mayer, 2002:226). Like the original Taxonomy, the revised Taxonomy is established on the view that schooling or learning can be extended to incorporate a complete range of cognitive development (Mayer, 2002:226).

Bloom identifies the two most important objectives for education that bring about a complete cognitive process after observing a range of subjects in senior secondary school levels, which if merged assures meaningful learning (Mayer, 2002:226). They are '*promote retention*' and '*promote transfer*' (Mayer, 2002:226). Retention is the capability to 'remember' something at a later stage as it was taught, and transfer implies to 'apply' learned material to new problems or situations (Mayer, 2002:226). Retention strategies which are also called memorization strategies work on promoting retention (recalling or 'remembering') whereas revision strategies work on promoting the 'transfer' of knowledge to new mathematical problems (Mayer, 2002). As expressed, the researcher concludes that 'retention strategies' consist of both retention strategies (memorization strategies) and revision strategies.

Therefore, there are two main types or categories of retention strategies. They are retention strategies, which are also known as memorization strategies, and revision strategies. In terms of the 'forget problem', there is a difference between retention and revision strategies. They are not the same thing. Retention refers to continuing to keep information learned in the memory. Revision is the act of practising or exercising. Retention strategies are associated with memorization of information (a process of attaching information to the memory) for them to be retrieved (recalled) later. Contrarily or variously, revision strategies have to do with practice/exercise so that that the material can be understood on a deeper level for knowledge transfer. Some of these practice problems require higher-order thinking or reasoning and gaining insight even in the things that were memorized. In other words, retention or memorization strategies work more on promoting recalling, whereas revision strategies work more on promoting the transfer of knowledge to new problems in mathematics (Mayer, 2010). However, retention and revision strategies have one common goal, "retention", a way to deal with "the forget problem".

There are plenty of different retention and revision strategies. Different retention/memorization and revision strategies produce retention based on their 'designs' (Julie, 2013). From this perspective, design means the plan/target or role for a particular strategy. This refers to whether the role of a strategy is recalling (retention strategy) or transfer (revision strategy). The benefits and restraints of each strategy depend on time constraints, fatigue and the number of participants (Steve et al., 2003:19). Actually, memory skills can be improved (Bah et al., 2019: 93).

Also, when a particular strategy should be applied matters. For example, memorization strategies such as mnemonics are more appropriate in helping learners recall formulas in mathematics rather than revision strategies. Finally, a strategy should authentically relate to the particular mathematical idea. This implies that some strategies can lead to accurate answers in mathematics but are false (unacceptable in mathematics); they don't make sense mathematically.

To clarify the argument above, an example is given below. A simple example is used to express what it is meant by authentically relating to a mathematical idea. Imagine explaining to learners how to convert a number expressed in standard form to decimal notation for example, ay, $285.5764 \times 10^2 = 285.5764 \times 100 = 28557.64$. The researcher observed some teachers tell learners that to get the answer, for each zero in the power, numbers on the right side of the point, starting with the first number should go to the left side of the point. This is rote learning because learners don't know why they have to do that; also because underlying reason related to 'place value' or powers of ten, is not brought into the procedures as an example. Telling learners that the zeros are about the powers of ten and place value makes sense to mathematics. Using a place value table to show that the place value is increasing or decreasing by powers of ten connects more authentically with mathematics. Applying mathematics to real-world problems increases both learners' interest and deep understanding. An example of the argument is explained below:

(Hint: Multiplying or dividing by 10)
E.g.: $8 \times 10 = 80$ $(add\ 0\ at\ the\ end)$ (This is a verbal comment on a procedure; it is the way learners/teachers speak.)
$So;\ 800 \times 10 = 8000$
Dividing by 10 is the opposite of multiplying by ten; therefore, the pattern is also the opposite.
$Therefore;\ 80 \div 10 = 8$ $(drop\ 0\ on\ the\ end)$ (This is a verbal comment on a procedure; it is the way learners/teachers speak).
∴ A number in standard form, with a positive index, is the same as multiplying a number by 10 or any other *power of ten (a).* Likewise, a number in standard form with a negative index is the same as dividing a number by 10 or a *power of ten (b).* E.g.:

a) 8×10^6

$= 8 \times 1\,000\,000$

$= 8\,000\,000$

b) 8×10^{-6}

$$= 8 \times \frac{1}{1\,000\,000}$$

$$= \frac{8}{1\,000\,000}$$

$$= 0.000008$$

∴ It is noticeable in the examples above that the number becomes bigger (increases) or smaller (decreases) by as many powers of ten as there are with multiplication and division respectively. In the case of the example above, this means the number increases or decreases by 6 places on the place value chart.

Using the place value pattern: (Hint: Place value when multiplying or dividing by 10)

When multiplying a number by 10 it indicates to move one place value bigger/larger (move your number to the left). Dividing by 10 is the opposite of multiplying by 10, so when you divide a number by 10 it indicates that you should move one place smaller (to the right). The idea of the place value table is to move your number right or left then, and fill in the zeros as required. A place value table is given below with more examples. E.g.:

a) 8×10^{6} c) 8.25×10^{6}

b) 8×10^{-6} d) $9.696969697 \times 10^{-5}$

WHOLE										**PARTS**							
MILLIONS			**THOUSANDS**			**ONES**			**DECIMAL .**	**ONES**		**THOUSANDTHS**			**MILLIONTHS**		
H	**T**	**Ones**	**H**	**T**	**O**	**H**	**T**	**O**	**.**	$\frac{1}{T}$	$\frac{1}{H}$	$\frac{1}{O}$	$\frac{1}{T}$	$\frac{1}{H}$	$\frac{1}{O}$	$\frac{1}{T}$	$\frac{1}{H}$
HM	TM	M	HTh	TTh	Th	H	T	O	.	$\frac{1}{T}$	$\frac{1}{H}$	$\frac{1}{Th}$	$\frac{1}{TTh}$	$\frac{1}{HTh}$	$\frac{1}{M}$	$\frac{1}{TM}$	$\frac{1}{HM}$
10^{8}	10^{7}	10^{6}	10^{5}	10^{4}	10^{3}	10^{2}	**10**	**O**	**.**	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	$10^{-(}$	10^{-7}	10^{-8}
a)		**8**	**0**	**0**	**0**	**0**	**0**	**0**	**.**								
b)								**0**	**.**	**0**	**0**	**0**	**0**	**0**	**8**		
c)					**9**	**6**	**9**	**6**	**.**	**6**	**9**	**6**	**9**	**7**			
d)		**8**	**2**	**5**	**0**	**0**	**0**	**0**									

Figure 2.2 Place value table

(*Adapted from*: D'Emiljo, 2012:10-11)

Analysing the table:

The strategy below can be used after the strategies above (which make more sense in mathematics) have been explained to the learners.

- The exponent values indicate how many zeros in a power of ten.
- For positive exponents, the exponent value indicates how many places of the powers of ten the point will move to the right while filling in the zeros as required.
- For negative exponents, the exponent value indicates how many places of the powers of ten the point will move to the left. Or simply, the exponent value indicates how many digits after the point (in the case of whole numbers.

E.g.: 8×10^6 can be considered as 8.0×10^6)

The examples provided above are given to make a point that retention and revision strategies also entail making sure that a strategy authentically relates to the particular mathematical idea, that is, whether they make sense mathematically. A teacher can use some strategies that can lead to accurate answers in mathematics but are false or unacceptable in mathematics.

2.3.1 Retention (memorization) strategies

These are mathematics strategies of instruction most appropriate for covering cognitive procedures associated with 'retention' or recalling of knowledge (Mayer, 2002:228-232). In other words, these are strategies that mostly demand assessment tasks that require the cognitive processes for promoting remembering.

Memorization is a repetition of skills until it can be recalled by heart (like a poem). It is a process of binding information to the memory. According to Hoque (2019:1) who did a study 'Memorization: A Proven Method of Learning', memorization should not be neglected at all. Nowadays, informed educators prefer creative teaching, creative learning, creative assessment and problem-solving rather than rote memorisation (Hoque, 2019:1). Although these skills are incredibly crucial and are a great way to learning, it is beneficial to point out that memorisation is still important to learning at both primary and secondary levels (Hoque, 2019:1). One cannot think and solve problems if they don't know a thing (Hoque, 2019:1).

It must be emphasised that memorisation is not learning by 'rote' but actually rote learning is only another alternative we are able to bind things to the memory (Hoque, 2019:2). Ideas can be memorised in a variety of ways and employing certain strategies such as mnemonics, visualization, rote learning and so on, so that one may learn large lists of numbers, names or just any large amount of things (Hoque, 2019:2). I think there are certain things that learners need to memorise for them to function effectively in every-day life (Hoque, 2019:2). For example, things like phone numbers, dates of births, names and addresses require memorisation (Hoque, 2019:2).

Memorization was researched and proven to be beneficial to learning not only mathematics but a variety of subjects at the secondary level. Learners at the secondary level memorise a large amount of vocabulary in language subjects. Unfortunately, they forget about them as soon as they don't get to use them. It is recognised to be beneficial for people to learn historical dates in History, for when they learn something new, they can connect or relate them to the dates that they already know so as to provide a point of reference in their minds (Hoque, 2019:2). In sciences and languages, teachers train their learners to memorise ideas using a variety of memorizations strategies such as mnemonics, connecting to emotions, memorable and visual images, visual and special techniques, memory palace techniques, lively visual metaphors or analogies as well as songs and music (Hoque, 2019:2). It is, however, important to explain to learners the reasons we have them memorise certain things, convince and make them understand that it will assist them to become more successful in their lives (Hoque, 2019:2).

According to Hoque (2019:2-4);
Some of the benefits of memorization are that memorization transit the human brain making it more flexible or receptive to recalling and offering its strength to retain more ideas or information. Challenges the human brain the same way one works out at the gym, it works out the brain for improved mental health. Memorisation enhances neural plasticity and researchers noted that increased exercises in rote learning and sustained stimulation of memory structures enhance neural flexibility in ageing brains. Memorisation provides a mental gymnastics workout or exercise making one's brain fit, sharp, fast and flexible. Memorisation is known to provide a mental gymnastics workout or exercise making one's brain fit, sharp, fast and flexible. Memorisation provides opportunities for teaching of rhythmic patterns, offering memorization through repetition. (This was found by researchers more beneficial to children teaching them symmetry and balance). Freeing up of brainpower is also one of the benefits of memorisation. The research noted that learners who 'just know' definitions, equations, functions or other memorised foundational ideas may save brainpower that can be used for bigger things. When foundational ideas are grasped or assimilated, learners will not have to waste time doing simple calculations on calculators or looking up concepts or words. Research indicates that learners who were expected to memorise things from an early age often went on to have an extra capacity to focus on school tasks or activities at secondary school and tertiary level.

Memorization also helps with the improvement in the learning of concepts: underdeveloped short-term memory was found to negatively affect learner's mastery of concepts in Mathematics and English. Research shows that learners who complete activities focused on developing short-term memory have improved in their working memory and ability to learn. Previous studies have reported that strong working memory is good for creativity just as good as it is for learning. Researchers noted that learners who sustain memory training stay sharp for more years (Hoque, 2019:2-4).

The above benefits of memorization have implications in terms of strategies for retaining and revising knowledge in school subjects. The specifics are what we examine next.

2.3.1.1 Mnemonics

A successful strategy in improving individual memory ability is mnemonics strategy (Bah et al., 2019:93). Mnemonic is from a Greek word meaning ‘to remember’ (Bah et al., 2019:93). Mnemonics were used by Greece and Rome over a thousand years ago. The study such as this of Bah et al. (2019:93), describes mnemonics as one of the memorization strategies that can be used to address the ‘forget problem’. Modern mnemonics implies memory driving strategies to remember ideas by relating them to easy kinds of data and information (Bah et al., 2019:94). Mnemonic guidelines (instructions) are strategies that provide verbal or visual prompt/stimulation for students who may have challenges in retaining or recalling information and connection to their world aids with long-term memory of the mathematics key concepts (DeLashmutt, 2007). The strategies of using and making up mnemonics make the remembering process easier because a mnemonic captures information in a way that is easy to recall.

The use of mnemonics can assist both learners and students from all stages either pre-school, primary, secondary or tertiary education to keep all commonly used and immediate information in mind (Bah et al., 2019:93). During the secondary level, learners are exposed to so much learning content that they are required to recall a lot of facts that can be mastered by applying mnemonic techniques. Besides easing memory, this strategy of mnemonics is very helpful in recalling a lot of intricate ideas as well as enhancing memory intake, reducing stress and aiding broadening of the memory scope (Bah et al., 2019:93).

According to Bah et al. (2019:93), this strategy demonstrates that it is possible to improve memory skills; the mind can recall things more than expected and appropriate choice of techniques will improve the memory process. Therefore, the use of mnemonics is very much required in the present and future, especially for learners who have a lot of important facts to bear in mind (Bah et al., 2019:93). The types of mnemonics used vary and individuals may use mnemonic methods that work or are appropriate for them. Among frequently used mnemonic strategies are keyword systems, chunking, loci methods, acronyms and acrostic strategies (Bah et al., 2019:93).

According to Bah et al. (2019:94) there are a variety of such methods:

Loci Techniques

Loci means using a location as a mnemonic technique that operates by relating or associating an object or place in a location known for something to be remembered by creating vivid mental images. Through visualization the loci techniques make recalling easier.

Visualization (Images/Model Mnemonics)

These are actual models and images for learners especially those who memorise well with pictures, charts, graphs, and similar devices. A triangle used to remind learners about the formulas for calculating 'Speed, Distance, and Time' is a common example of a model mnemonic used in secondary mathematics.

Keyword systems

This means associating visually and verbally equivalent words.

Connect Technique

The connect system entails associating or relating one word to another forming a logical and illogical or unrealistic relationship that can trigger your memory. This idea is consistent with Hoque (2019:6) regarding chunking or grouping words and ideas or activities. This means to group things in categories to make it easier for them to be remembered. Learners can place a word before/after or next to the word they would like to remember. For example, when they would like to remember the word 'Fragile', they could think of it as 'breakable, fragile vase' Hoque, 2019:6). In the same way, mathematical concepts become easy to remember.

Acronym

This means creating a word from the first letter of a progression of words or phrases. These are also called name mnemonics. The name helps the learners memorise the associated idea. One common mnemonic used in secondary mathematics is 'PEMDAS' used for remembering the order of operations in algebra which means: parenthesis, exponent, multiplication, division, adding and subtraction. The first letters of the words can also be used to create new words forming a memorable phrase (e.g. PEMDAS - Please Excuse My Dear Aunty Sally). These are called expression mnemonics. A mnemonic such as 'CAST' (Cosine, All, Sine & Tan) is an example of an acronym used to assist us recall the trigonometric functions signs in the quadrants (Quadrant Rule) used to help us solve trigonometric equations in a given range.

Acrostic

Acrostic-like acronyms also make use of key letters making the abstract idea more concrete and easier to remember. However, acrostic does not necessarily form abbreviations or use the first letter all the time; it can be a certain phrase or word. Acronyms are one of the mnemonic techniques mostly used in mathematics.

A mnemonic such as 'SOHCAHTOA' is also an example of an acronym, a visual and verbal prompt, used to help learners remember how to express trigonometric ratios. F, U/C and Z angles are used for angles formed within parallel lines in angle properties, to mention a few examples. 'Kyk Hy Dance Met Die Cowboy Meisie', is used for "Kilometre, Hectare, Decametre, Meter, Centimetre and Millimetre" is an acrostic-like acronym strategy, a verbal prompt used to help learners remember how to convert between different Standard Units (SI units) of length.

A seven column table is also used as a visual prompt in the case illustrated below. Noting that each *standard* unit is 10 times smaller or larger than the previous, the conversion between the units is thus about dividing (when converting from a smaller to a bigger unit) or multiplying the unit (when converting from a bigger to a smaller unit) by 1 followed by as many zeros as there are places between them in an order of magnitude. Having been a secondary mathematics teacher as well, the researcher has observed and used some these strategies.

E.g. Convert:

a) 38 mm into cm
b) 14 m into mm
c) 6mm into m

Km			**m**		**cm**	**mm**
					3 .	8
					0	0
			1	4	0	6
			0 .	0		

Figure 2.3: An example of a seven column table

1. Draw and label the seventh table

2. Fill in the original measurement

3. Put the decimal point to the right-hand side of the target unit

4. Fill in the zeros appropriately

According to Bah et al. (2019:95), some technical principles of mnemonics must be addressed:

- Use visuals or mental images. Visual images are easier to remember compared to words.
- Should be meaningful, making interesting or memorable or relevant can move ideas from short-term to long-term memory.
- Link information to existing knowledge. Make or present information an ordinary idea.

Mnemonics are used over a wide range of subjects from pre-schooling to secondary school and even tertiary level. One of the familiar mnemonic devices that learners use in subjects such as physical science is an acronym (ROYGBIV) which learners should pronounce as 'ROY-G-BIV'. It is used to remember the seven colours of the rainbow. Every letter stands for one colour such as Red, Orange, Yellow, Green, Blue, Indigo and Violet. Have learners come up with any sentence that they can associate with what they wish to remember (Hoque, 2019:6). For example, in secondary school, we used an acrostic-like acronym or sentence 'Richard Of York Gave Battle In Vain' to remember the rainbow colours. Mnemonic devices have been carefully researched and have been confirmed as one of the helpful ways to assist learners in recalling information skilfully (Hoque, 2019:2). The use of mnemonics, therefore, contributes to insightful learning.

2.3.1.2 Advance organizers

Advance organizers were developed by David Ausubel in 1960 in his theory of meaningful verbal learning (Kirkman & Shaw, 1997:3). As stated earlier in this chapter, in David Ausubel's view, learners must link new material (ideas and suggestions) to their existing knowledge, to learn meaningfully (Novak, 2002:549). Ausubel proposed the idea of 'advance organizers' as a way to assist learners to connect their existing ideas with new concepts or material (Kirkman & Shaw, 1997:3). Ausubel's learning theory argues that new ideas can be incorporated or 'organized' into more inclusive ideas or concepts. The more inclusive ideas or concepts are advance organizers. Advance organizers are instructional approaches used to enhance learning and retention of new knowledge learned. An advance organizer is a small amount of visual, verbal, graphic or written information that is given to learners prior to new learning material during an instructional session (Lefrancois, 1997, cited in Guthua & Nyabwa, 2008). Others refer to it as an instructional approach used to enhance learning and retention of new knowledge/learning material (Ames, Ackerson & Luiten, 1980). An advance organizer functions as a road map to direct learners over a new material (Guthua & Nyabwa, 2008).

Advance organizers are normally given at the beginning of a lesson or series of lessons in order to unfold and advance or guide learners' thinking (Eggen, Harder & Kauchaak, 1979, cited in Guthua & Nyabwa, 2008). Learners could read an advance organizer passage or statement and subsequently complete the material to be learned. This is normally information that is organised in a way that is simplified or made easier to be taken up by the memory.

David Ausubel believed that learning continues in a deductive (top-down) manner. Ausubel's theory of learning consists of three stages: an advanced organizer presentation, learning material or task presentation, and strengthening of the cognitive organization (Novak, 2002). The main components of Ausubel's model are illustrated in the figure below.

Stage 1: **Presentation of an Advance Organizer**	**Stage 2:** **Presentation of Learning Material or task**	**Stage 3:** **Establishment of Cognitive Organization**
-Clarity of aim of the lesson. -presentation of the organizer. -Link organizer to learners' knowledge.	-Make the arrangement of the new task clear (explicit or unambiguous). -Make coherent order of learning task clear. -Present task and engage learners in meaningful learning exercises/activities.	-Connect new information to the advance organizer. -Develop engaged reception learning.

Figure 2.4 Ausubel's Learning Model

(*Adapted from*: Novak, 2002)

Thus, in terms of mathematics, advance organizers are about showing the layered meanings of mathematics concepts/ideas or chunked items in categories in order to make it easier to remember. Advance organizers just like mnemonics, form part of memorization/retention strategies that aid with deep mathematical insight. These strategies can be symbolic, tabular, graphical, verbal and/or visual.

Examples of advance organizers are for example Venn diagrams or KWL (Know Want/Wonder Learn) charts/diagrams, which stand for What I already know, what I Wonder/Want to find out, what I Learned.

Figure2.5: An example of a model of a K-W-L Chart

(*Adapted from:* https://graphicmama.com/blog/infographic-powerpoint-templates/)

Examples of the KWL idea in the case of Mathematics

Laws of Indices

The laws of indices below were adapted from D'Emiljo (2012:82-83), and an example of a KWL idea provided hereafter was developed from the laws of indices.

Converting powers with positive indices and vice versa:

Law 1. $x^a \times x^b = x^{a+b}$

-When the same bases of powers are multiplied, the indices are added

Law 2. $x^a \div x^b = x^{a-b}$

-When dividing powers of the same base, subtract the indices

Law 3. $(x^a)^b = x^{ab}$

$(xy)^a = x^a y^a$

$\left(\frac{x}{y}\right)^a = \frac{x^a}{y^a}$

-When a power of a base is raised to a further power, the indices are multiplied

Law 4. $x^0 = 1;\ [x \neq 0\,]$

$x^0 = 1$, for any value of x which is not 0 (Zero)

0 (Zero) is undefined

Law 5. $x^{-a} = \frac{1}{x^a}$

$\frac{1}{x^{-2}} = x^2$

- A negative index means that an index value is negative. It indicates that a reciprocal must be taken.

  When converting powers with –ve indices make reciprocal.

Converting powers with fractional indices

Law 6. $x^{\frac{1}{a}} = \sqrt[a]{x}$

Or

$\sqrt[z]{x^y} = \frac{y}{x^z}$

Or

$\sqrt[z]{x^y} \;= \left[\left(\left(\sqrt[z]{x}\right)^y\right)\right]$

- Fractional indices:
- Fractional indices are indices that are expressed as common fractions

  The numerator determines the index the base should be raised to.
  The denominator determines the root to be drawn.

The outline of the KWL idea below was compiled and developed from the laws of indices adapted from D'Emiljo (2012:82-83), as described above, that can be done with the learners as subsequent lessons/practice sessions.

Example 1:

What I know (What the learners were already taught):

$E.g. 3^3 \times 3^2 = 3 \times 3 \times 3 = (3 \times 3) = 3^5 = 3^{3+2}$

- Converting powers with positive indices and vice versa:
- When the same bases of powers are multiplied, the indices are added (Law 1).

What I wonder:

$E.g.\ 9^{\frac{1}{2}} \times 9^{\frac{1}{2}}$

- Converting powers with fractional indices to numbers.

What I Learn:

$9^{\frac{1}{2}} \times 9^{\frac{1}{2}} = 9^{\frac{1}{2}+\frac{1}{2}} = 9$ *(Laws of indices)*

- Fractional indices are indices that are expressed as common fractions.

(Equal bases)

Example 2:

Subsequent to example 1

$E.g.$: *What I know*:

$9^{\frac{1}{2}} \times 9^{\frac{1}{2}} = 9^{\frac{1}{2}+\frac{1}{2}} = 9$

$\boldsymbol{or}$

$8^{\frac{1}{3}} \times 8^{\frac{1}{3}} \times 8^{\frac{1}{3}} = 8^{\frac{1}{3}+\frac{1}{3}+\frac{1}{3}} = 8^{\frac{3}{3}} = 8$

What I wonder:

$E.g.$The meaning of $9^{\frac{1}{2}}$ or $8^{\frac{1}{3}}$ or

Why $9^{\frac{1}{2}} = \sqrt[2]{9}$

$\boldsymbol{or}$

Why $8^{\frac{1}{3}} = \sqrt[3]{8}$

What I Learn:

$9^{\frac{1}{2}} \times 9^{\frac{1}{2}} = 9^{\frac{1}{2}+\frac{1}{2}} = 9$

$\sqrt[2]{9} \times \sqrt[2]{9} = 3 \times 3 = 9$

$\therefore 9^{\frac{1}{2}} = \sqrt[2]{9}$

$\boldsymbol{or}$

$8^{\frac{1}{3}} \times 8^{\frac{1}{3}} \times 8^{\frac{1}{3}} = 8^{\frac{1}{3}+\frac{1}{3}+\frac{1}{3}} = 8^{\frac{3}{3}} = 8$

$\sqrt[3]{8} \times \sqrt[3]{8} \times \sqrt[3]{8} = 2 \times 2 \times 2 = 8$

$\therefore 8^{\frac{1}{3}} = \sqrt[3]{8}$

- Fractional indices.
- The numerator determines the index the base should be raised to.
- The denominator determines the root to be drawn.

Example 3:

Subsequent to examples 1 & 2

What I know:

$E.g.$

$a)\ 8^{\frac{1}{3}} = \sqrt[3]{8}$

$\boldsymbol{or}$

$b)\ 27^{\frac{1}{3}} = \sqrt[3]{27}$

- Fractional indices.
- The numerator determines the index the base should be raised to.
- The denominator determines the root to be drawn.

$b)\ (3^2)^3 = 3^2 \times 3^2 \times 3^2 = 3^6 = 3^{2\times3}$

- Powers rose to powers
- We multiply indices when a power is raised to a power.

What I wonder:

$E.g.$

1. Calculate using indices

a) $\sqrt[3]{8}$

b) $\sqrt{81}$

c) $125^{\frac{1}{3}}$

d) $64^{-\frac{1}{3}}$

2. Write the index in the root form

a) $64^{\frac{2}{3}}$

b) $125^{-\frac{2}{3}}$

What I Learned:

1.

a) $\sqrt[3]{8} = 8^{\frac{1}{3}} = (2^3)^{\frac{1}{3}} = 2$

b) $\sqrt{81} = 81^{\frac{1}{2}} = (3^4)^{\frac{1}{2}} = 3^2 = 9$

c) $125^{\frac{1}{3}} = (5^3)^{\frac{1}{3}} = 5$

d) $64^{-\frac{1}{3}} = (2^6)^{-\frac{1}{3}} = 2^{-2} = \frac{1}{2^2} = \frac{1}{4}$

2.

a) $64^{\frac{2}{3}} = \sqrt[3]{64^2}$

b) $125^{-\frac{2}{3}} = \sqrt[3]{\frac{1}{125^2}}$

2.3.1.3 Drill-&-Practice

Drill-and-practice is a 'routine based on tricks' (Van Dormolen, 1975, as cited in Kindt, 2011: 138). This simply means learners take methods as habitual activities that they should repeat. This is an approach or method of training defined by organized and ordered reiteration of ideas or theories, examples and practice problems that are repeated until they are performed successfully and precisely to get a correct answer as per instruction. After all, it is just another type of memorization. An example to express the argument above is given below.

When learners are taught how to find the n^{th} term of a geometrical sequence such as 30; 15; 7.5; 3.75; 1.875; 0.9375 for example, learners could manage to find the correct 7th term or any other term with countless exercises in the class by following the formula $T_n = ar^{n-1}$ but be unable to use the same formula in other appropriate situations if they have only memorised the formula without the insight of how the formula came about. This could happen even when they are taught that a is the first term in the sequence and r is $\frac{T_2}{T_1}$.

Learners should have the skill to know that;

- a (T_1) needs to be multiplied with the difference 6 times in order to get the 7th term but
- The 6th term needs to be multiplied with the difference only once to get the 7th term. Thus both;
- $30\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)\left(\frac{1}{2}\right)$ or 0.9375×0.5 will give the correct answer 0.46875.

Another example, as explained earlier in this section, SOHCAHTOA is a verbal/visual prompt (retention/memorization strategy) which helps learners to recall how to express the trigonometric ratios. However, learners still need a variety of practices (revision strategies) to be able to connect previous knowledge to new challenges and new ways of questioning to be able to solve a variety of problems involving the trigonometric ratios, hence revision strategies. According to Van De Wale et al. (2010:69), in the interest of acquiring a different view on drill and practice, suggest considering the terms as two separate ideas rather than connecting them. Practice entails a variety of problem-based tasks that are spread over several classroom periods, each addressing the same ideas; drill indicates repetitive exercises, non-problem-based, intended to advance procedures already learned (Van De Wale et al., 2010:69). This definition, therefore, suggests that not all drill and practices are rote and can contribute to meaningful learning.

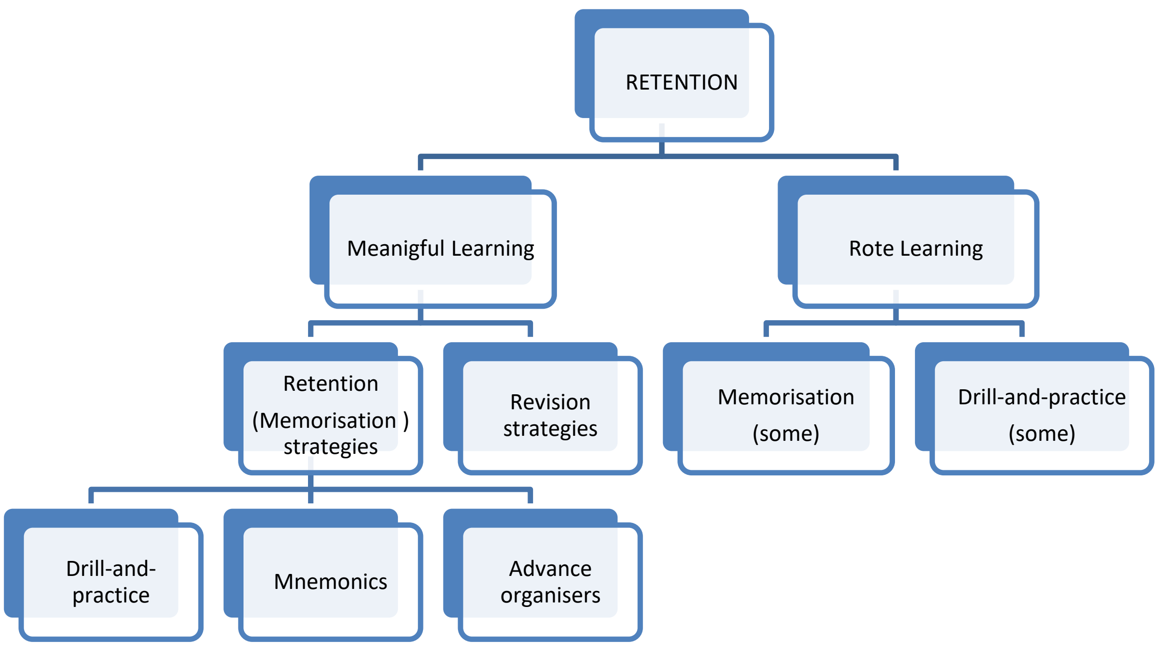


Figure 2.6: An example of a model of relationships for retention strategies and revision strategies

(Adapted from: Microsoft Office Word Smart Art Tools)

The diagram outline above is established on the revised Bloom's Taxonomy on meaningful learning (Mayer, 2002:228-232). Meaningful learning derives from combining the cognitive processes of the two most important goals of education 'promote *retention*' and 'promote *transfer*' (Mayer, 2002:226). The revised Bloom's Taxonomy comprises of six complex process groups; they are *Remember*, *Understand*, *Apply*, *Analyse*, *Evaluate* and *Create* (Mayer, 2002:232).

The revised Taxonomy constitutes 19 particular cognitive processes that are identified with the six categories. Two of these specific cognitive processes are related to *remember* (Mayer, 2002:232). The rest (17) are associated with the other five complex cognitive processes (Mayer, 2002:232). Therefore, two specific cognitive processes are identified with '*retention strategies'* whereas the other 17 are related to *'revision strategies'*. The cognitive process group of retention is *Remember*.

The primary goal of meaningful learning is to explore how teacher instruction and assessment can be expanded beyond focusing on a single cognitive process of *Remember* (Mayer, 2002:232). The revised Taxonomy is aimed at helping broaden the common set of educational goals to include those intended to promote transfer (also see figure 2.5). Retention is the ability to remember something at a later stage as it was presented (Mayer, 2002:226).

According to Mayer therefore: the cognitive processes in the category of *Remember*, hence, are *recognizing* (*identify*) and *recalling* (*retrieve*). These imply that when the objective of teaching or the lesson is to 'promote *retention*'; the objectives, instruction or questions and the strategies to be employed thereof are those that enforce *retention* or *Remember* (retention strategies). In other words, the objectives should incorporate the cognitive processes associated with Remember. The same applies to *transfer* or *revision* (revision strategies).

2.3.2 Revision strategies

These are mathematics instruction strategies most suitable for including cognitive processes associated with 'transfer' of knowledge (Mayer, 2002:228-232). In other words, these are strategies that most enable assessment tasks that deal with cognitive processes that promote transfer of learning. The specifics are explored below.

2.3.2.1 Massed practice

Once a certain method (way of solving a problem) has been taught, similar practice problems can be accumulated ('massed') into one assignment/session (Rohrer & Taylor, 2006). 'Massed practice' implies that practice questions from the same topic collected into one practice session. There is no variation in the questions, learners do the same. This implies that learners complete five or ten problems in one session. Massed practice is normally described as a method or procedure that takes place with no rest amid trials (Burdick, 1977, as cited in Steve et al., 2003:19). Simply, the massed practice can be defined as a continual practice with a few or no pauses (Steve et al., 2003:19).

Massed practice can contain small quantities of rest; still, it only grants small breaks amid trials (Schmidt, 1991, as cited in Steve et al., 2003:19). These imply that massers can have some amounts of rest but only small amounts in between trials or similar practice problems within one practice session. Just like all other retention strategies, the benefits and limitations of massed practice depend on time restraints, fatigue and the participants' number (Steve et al., 2003:19).

Thus, continual task incorporating massed practice can have destructive or harmful effects on performance due to fatigue; anyway, learning is only affected to a small degree during transfer testing on retention (Schmidt, 1991, Stelmach, 1969, as cited in Steve et al., 2003:19). Research indicates that massed practice particularly affects performance but not learning (Steve et al., 2003:21).

2.3.2.2 Overlearning

Similar practice problems can be spread across two or more assignments/sessions; this is known as 'overlearning' (Rohrer & Taylor, 2006). 'Overlearning' requires that similar practice problems are distributed across two or more practice sets. With overlearning, learners initially master or grasp a skill and instantly exercise the same skill (Rohrer & Taylor, 2006). In a typical overlearning experience, learners stop studying upon their achievement of a criterion accurate instance or trial (Rohrer & Taylor, 2006). Usually, overlearning boosts these succeeding test scores (Rohrer & Taylor, 2006).

However, the effects of overlearning on long-term retention are questionable as the experiences of overlearning have always used fairly brief RIs (the non-trivial retention interval), the timeframe separating the test and the latest teaching period (Rohrer & Taylor, 2006). This means that the benefits of this particular strategy have no effect or impact on test performance one or four weeks later (Rohrer & Taylor, 2006). The overlearners may recall or achieve good test scores at one-week tests but these scores drastically drop thereafter (Rohrer & Taylor, 2006). Research indicates that with the manipulation of the RI, the benefits of overlearning may disappear with time (Rohrer & Taylor, 2006). A study by Rohrer and Taylor (2006) suggested that overlearning with its accompanying extra study time demands is inefficient for meaningful learning, for long-lasting retention. Thus, Rohler and Pashler (2007:1) did a study investigating how retention is affected by the length of a study period and the temporal distributing (spacing) of the study across different study sessions. Their results suggested that skill should be learned or practiced long enough until it is mastered by the learners but instant additional study or practice of the same learning material is a wasteful use of time Rohler & Pashler (2007:1).

2.3.2.3 Distributed practice

'Distributed practice', also referred to as 'spaced practice', entails distributing a variety of practice problems (practice problems from different topics) over two or more practice sets (Rohrer & Taylor, 2006). Distributed practice is commonly referred to as 'practice infused with rest or alternative skill learning' (Burdick, 1977, as cited in Steve et al., 2003:19). Distributed practice is also defined as a practice procedure where the amount of resting time amid practice trials is long relative to the trial duration (Schmidt, 1991, as cited in Steve et al., 2003:19). Schmidt (1991) adds that when a practice is distributed, the amount of rest separating the trials can be equivalent to or more than the duration of the trial (Steve et al., 2003:19). The period of time separating two sessions is called the inter-session interval (ISI) and the non-trivial retention interval (RI) is the interval between the test and the latest learning session (Rohrer & Taylor, 2006). So, the spacing practice is recommended, especially when the gap between the latest learning session and the test is delayed.

Many researchers recommend that educators rely on spacing or distributed practice for longer RIs (Rohrer & Taylor, 2006). A number of researchers have reported that distributed practice is the most effective strategy to maximize performance and learning (Steve et al., 2003:20). However, even at lengthy RIs, the benefits of distribution or spacing are not that convincing for conceptually challenging tasks compared to those that only demand word to word recall (Rohrer & Taylor, 2006). This is because research indicates that for conceptually demanding work; even shorter RIs at times doubtlessly benefited the spacers compared to the massers. Studies of Rohler and Taylor have found that long-term retention is improved by distributed practice while unchanged by overlearning. Nonetheless, distributed practice is one of the revision practices highly recommended for meaningful learning.

2.3.2.4 Examination-Driven Teaching

'Examination-driven teaching' (EDT) is normally regarded as teaching the material of past examinations and questions assumed to emerge in the upcoming examinations (Julie, 2013b:3). EDT is an approach based on assumptions of what is most likely to be tested in the examination. The other terminologies used for examination-driven teaching are assessment-driven instruction (ADI), measurement-driven instruction (MDI), and data-driven instruction (DDI). According to Julie (2013b:3), examination-driven teaching (EDT) is also known for a weak conception of 'teaching to the test'. This is perceived as teaching and learning practices that stress on repetition, expertise established on instructions rather than critical and theoretical oriented thinking, minimal rich curriculum material use, reduced teacher decision making and pedagogical design flexibility, and the threatening sanctions that comes with not meeting externally established performance requirements (Davis & Martin, 2006:10, cited in Julie, 2013b:3).

Some studies have, however, focused on the consequences that the EDTs have on the learners and teachers and demonstrate a strong view on exam-driven teaching (Julie, 2013b). Popham (1987:680) contends that measurement-driven instructions are instances where high stakes examination of educational achievement influences the teaching process that prepares learners for the examination (Julie, 2013b:3). Some advantages known for 'EDT' are, for example, clear objectives, cost-beneficial way to enhance the standard of education, the motivation of learners due to clear objectives, and providing teachers with beneficial feedback necessary for informing teaching or instructional decision making (Popham, 1987; Shepard & Cutts-Dougherty, 1991; Wayman, 2005, cited in Julie, 2013b:3).

Others focused on advantages of 'EDT' such as; lack of complexity in curriculum material usage, limited teacher instructional flexibility, limited flexible knowing, loss of disciplinary consistency, curriculum contraction, irrational time used on test preparations, stress and demoralization for teachers, and deskilling of teachers (Julie, 2013b:4). These imply limits of teachers' curriculum coverage, excessive time spent on test preparations leading to stressing and demoralizing teachers, prevention of teachers by approaching the curriculum from different angles or using new ways of teaching, leading to teachers' loss of innovative or quality mathematics practices, instructions or strategies that link or connect the way of writing to particular mathematics tasks or processes for the learners to acquire all the necessary abilities required in the subject of mathematics, and criterion underlying the major high-stakes examination or tests are not favourable for creating proper instructional decisions and thus not conducive for meaningful learning (Davis & Martin, 2006; Furner and Kumar, 2007; Hagan, 2005; Gilmour, Christie, Van den Heuvel-Panhuizen & Becker, 2003; Shepard & Cutts-Dougherty, 1991Soudien, 2012), cited in Julie, 2013b:4). Overall, the opponents of exam-driven practice suggest that exam-driven teaching creates an unhealthy focus on needless repetition of simple confined skills ('drill and kill') and minimises the teachers' capacity or prevents the teachers from focusing on a holistic appreciation of the subject material. All the above are considered to reduce the skills of the teachers regarding the ways of teaching that benefit learners' achievement. 'EDT' therefore, as a usable revision strategy on its own, cannot result in meaningful learning.

However, 'EDT' carries the potential for improving achievement in high-stakes school mathematics tests and examinations if reasonably and delicately executed (Julie, Mbekwa & Okitowamba, 2018:1). Van den Heuvel-Panhuizen and Becker (2003), and Burkhardt and Pollak (2006, cited in Julie, 2013), argue that it will always be what is examined that will drive the teaching regardless of a number of the disadvantages of EDT. Therefore, the examined curriculum tends to determine the implemented curriculum (Bishop, Hart, Lerman & Nunes, 1993:11, cited in Julie, 2013b:4; Okitowamba, 2018:4). The researcher agrees with these preceding statements because the schooling system is established on three versions of the curriculum; the intended (legitimate predetermined curriculum), the implemented (what the teachers teach) and the examined (what is examined). The intended and interpreted curriculum determines the teaching scope but the implemented curriculum should abide with the examined curriculum (Julie, 2013b; Okitowamba, 2018:4).

Julie (2013b:13) contends that examination-driven teaching can contribute to meaningful learning. The researcher concurs with the aforementioned statement because aspects of meaningful teaching can be incorporated in exam-driven teaching (2013b:1). 'Productive practice' discussed below is one of 'the elements of *meaningful teaching* that can be incorporated into Examinations-Driven Teaching' (Julie 2013b:7).

2.3.2.5 Productive practice

'Productive practice' implies presenting learners with practice and problems that stimulate or promote 'deepening thinking' to expand their general strategies of working in school mathematics, while practising work previously covered (Julie, 2013a:93). The productive practice is made up of 'spiral revision' and 'deepening mathematical thinking', implying that learners revise exam-like problems in a spiral manner and revision enables them to deepen their mathematical thinking through justifying their solutions (Julie, 2011:4). 'Productive practice', spiral revision', 'deepening mathematical thinking' and 'examinations-driven teaching' are notions that emanate from the University of Western Cape-based project known as the Local Evidence-Driven Improvement of Mathematics Teaching and Learning Initiative (LEDIMTALI). This is a project which is currently running in South Africa promoting the development of mathematics teaching.

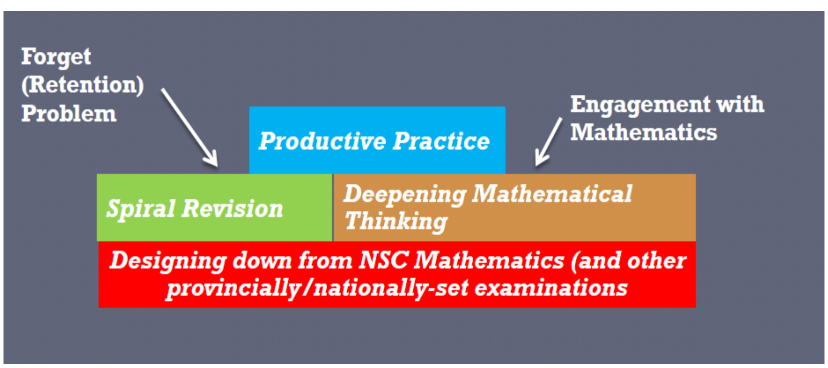


Figure 2.7: Teaching model for the development of teaching

(*Source*: Julie, 2013b)

Productive practice generally is a set of mathematical exercises and activities given to learners to revise topics that have already been covered in teaching. Productive practice is framed around sets of exercises and activities, every set consisting of up to three examination-like problems (Julie, 2011:2). These activities are done regularly (spirally).

The nature of these activities is more or less the same to the types of questions asked in the National Senior Secondary Certificate Examination (Julie, 2011:2) to enhance or deepen learners' mathematical thinking. This is how the notion of 'spiral revision' and 'deepening mathematical thinking' emerged.

2.3.2.5.1 Spiral revision

The ideas of 'productive practice' and 'spiral revision' were developed in the early unceasing professional initiative (Selter, 1996, as cited in Julie, 2013a:93). These ideas were developed in response to a problem of learners not doing homework (Julie, 2013a:93). It was established on the belief that by practising repeatedly learners will become more familiar with strategies for solving various kinds of mathematical problems that they are likely to be faced with in high-stakes examinations (Julie, 2013a:93). 'Spiral revision', is LEDIMTALI project's version of distributed practice. It has overlaps with distributed practice. 'Spiral revision' resulted from the concern by the teachers from the LEDIMTALI project about learners' reluctance about doing homework, which was believed to contribute to 'the forget problem'. 'Spiral revision' was therefore a strategy invented to deal with the view of exercising of skills and procedures in class instead (Julie, 2013a:93). 'Spiral revision' entails learners practising past taught/learned work through a variety (a focus on different ideas/topics) of short examination-like exercises and activities so that what was taught can be developed (Julie, 2013a). Because of its distributed effect, it is therefore also one of the revision strategies greatly approved for insightful learning.

2.3.2.5.2 'Deepening Mathematical Thinking' (DMT).

Deepening mathematical thinking refers to the instances where learners have opportunities to engage with mathematics (Julie, 2011). By this DMT, learners' engagement with mathematics is advanced by providing them with learning, teaching environments and challenging mathematical problems that reinforce deep understanding, ability to elaborate and motivate solutions as well as the ability to reflect on their working (Julie, 2011). These environments and activities also teach learners that struggling is part of learning mathematics ('disposition of productive struggle'), which encourages creativity, builds authentic engagement and perseverance. If learners say answers out of the blue, one would never know whether they have guessed or whatever. But if the learners understand something, they can also justify their answers. So, it's a means of showing or demonstrating understanding. Normally a set of the 'DMT' comprises of a single exercise problem only.

A brief distinction between 'spiral revision' and 'deepening mathematical thinking' is that spiral revision can involve all of the levels of cognitive processes whilst deepening mathematical thinking focuses on higher order thinking (beyond the cognitive process of remembering).

An example of a productive practice set containing three classroom activities for grade 11 and 12 below is adapted from LEDIMTALI Brochure (Julie, 2011). The example illustrates Ledimtali's ideas around what one productive practice set looks like.

Practice set:

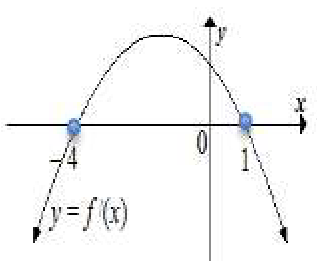
1. $(2x-4)(2x+4)=0$ (4)

(*Source*: *Adapted from* D' Emiljo, 2012:65)

2. If $f\ (x)=x^2-6x$, find $f'(x)$ from first principles. (5)

(*Source*: *Adapted from* Statistical Research Unit (SIR) Unit, 2018:14-15, [UMALUSI])

3. The graph of $y=f'(x)$, where f is a cubic function is sketched below.



(*Source*: LEDIMTALI Grade 11&12 Brochure, 2011:16)

Answer the following questions using the graph above:

3.1 For which values of x is the graph of $y=f'(x)$ decreasing? (1)

3.2 For which x value is the graph of $y=f'(x)$ increasing? (1)

3.2 At which value of x does the graph of f have a local minimum? Motivate your answer. (3)

(*Source*: *Adapted from* LEDIMTALI Grade 11&12 Brochure, 2011:16)

Below are a few examples of 'DMT' classroom activities for grade 11 and 12:

1. Learners can be asked why the formula to calculate the area of a circle is A=πr^2 for 15 marks. When learners can logically come to the formula A=πr^2, it means they know and understand what area means, they know and understand why the formula is the way it is. Thus, they can be accountable for their answers and this helps them to recall it better during the exams.

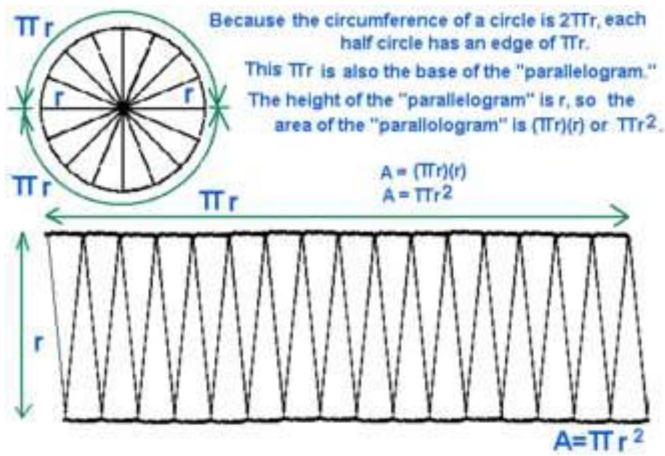


Figure 2.8: "Development of the circle area formula"

(How to logically come to the formula for calculating the area of a circle)

(Source: Adapted from Van De Walle, Karp and Bay-Williams, 2010:395)

2. Learners can also, therefore, be asked if the statement $(6x)^2 = 36x^2$ is correct or if $(3a)^2 = 3a^2$ is correct for 10 marks. Another example can be asking if gradients of three different straight lines e.g. lines A, B and C on a Cartesian plane are the same for 10 Marks. These questions demand more thinking and the marks allocation shows that instead of learners answering only yes or no, they would be required to show their sound understanding through showing their working to justify their answers.

Examples of more complex problems (complex procedures) for grade 11 and 12:

Complex procedures entail higher order reasoning or complex calculations (Statistical Information and Research (SIR) Unit, UMALUSI, 2018). Complex problems, thus, imply that high levels of thinking are required. The examples of activities or problems provided below can be challenging (DMT) for learners because they generally demand learners' deep understanding and/or interpretation of mathematical concepts and procedures (Julie, 2011:2).

Moreover, some problems mostly do not require a direct route or procedure to the solution (Statistical Information and Research (SIR) Unit, UMALUSI, 2018).

1. The letters of the word "DECIMAL" are arranged randomly into a new "word", also consisting of seven letters. How many various arrangements are possible if:
These arrangements must begin with a vowel and end with a consonant and letters can be repeated. (4)
(*Adapted from:* Statistical Information and Research (SIR) Unit, UMALUSI, 2018).

2. A quadratic equation in standard form is provided on the chalkboard. Hilda and Paulina copied it wrongly in their workbooks. Hilda copied the constant wrongly and obtained $x = -2$ or $x = 2$ as her solution. Paulina copied the middle term incorrectly and obtained $x = 1$ or $x = -15$. What was the original (correct) equation provided on the chalkboard? (4)

(*Adapted from:* Julie, 2011:8)

'DMTs' are found to have long-lasting benefits to meaningful learning and thus long-term retention.

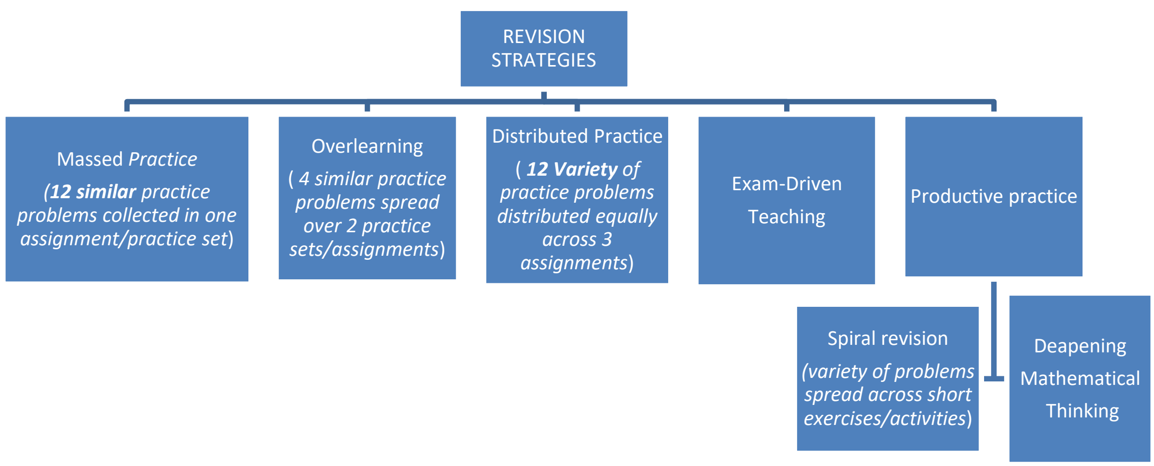


Figure 2.9: An example of a model for revision strategies

(Adapted from: Microsoft Office Word SmartArt Tools)

Figure 2.9 illustrates the various revision strategies of massed practice, overlearning, distributed practice, examination-driven-teaching and productive practice. Spiral revision and deepening mathematical thinking form productive practice. The outline of the figure above is adapted from the revised Taxonomy of Educational Goals. The 5 complex cognitive processes associated with '*transfer*' are *Understand*, *Apply*, *Analyse*, *Evaluate* and *Create* (Mayer, 2002:232). The cognitive procedures in the level of *Understand* involve *interpreting (paraphrasing, clarifying, translating* or *representing*), *classifying (subsuming* or *categorizing*), *exemplifying (instantiating* or *illustrating*), *inferring (interpolating, extrapolating, predicting* or *concluding*), *summarizing (generalizing* or *abstracting*), *explaining* (*constructing models*) and *comparing (mapping, matching* or *contrasting,*) (Mayer, 2002:228-229). *Apply* includes using techniques for doing exercises or solving problems and is nearly associated with procedural knowledge (Mayer, 2002:228). The *Apply* level comprises of two cognitive procedures of *executing* (*carry out*) and *implementing* (*using*) (Mayer, 2002:229). *Executing* applies when the learner is familiar with the task and *Implementing* happens when learners apply methods to familiar tasks (Mayer, 2002:229). *Analyse* requires breaking materials into their constituent components and verifying how they are linked to each other and a complete structure. The cognitive processes in the *Analyze* category include *organizing*, *differentiating (selecting, discriminating, distinguishing,* or *focusing*) and *attributing (deconstructing*).

Evaluate requires providing judgments based on standards and criteria (Mayer, 2002:230). This level includes *checking* (*detecting, monitoring, coordinating,* or *testing*) and refers to internal consistency judgments and *critiquing* (*judging*) which refers to external consistency judgments (Mayer, 2002:230-231). *Create* involves placing aspects together to obtain a consistent new structure (Mayer, 2002:231). *Create* is split into three consecutive cognitive processes of *generating* (*hypothesis*), *planning* (*designing*) and *producing* (Mayer, 2002:231-232). These entail that when the objective is aimed at 'promoting *transfer*', the instruction, questions or strategies should be those that reinforce '*transfer*'. In other words, when the aim is to improve '*transfer*', the learning objectives should involve the cognitive procedures associated with Create, Evaluate, Analyse, Apply and Understand (revision strategies).

2.4 RELATIONSHIPS AND INTERRELATIONSHIPS BETWEEN RETENTION AND REVISION STRATEGIES

This section will explain how retention and revision strategies come together and ought to work together for one goal which is the retention of school mathematics.

Retention, in general refers to the condition of continuing to keep something. Retention is the potential to recall something at a later stage as it was presented (Mayor, 2002:226). From a school mathematics perspective, retention refers to continuous possession of learned information in the memory in such a way that it can be effortlessly or easily retrieved with the application of this mathematical knowledge to unfamiliar and practical situations. According to the researcher's understanding, it is the act of absorbing and continuing to hold learned information. In brief, it is the assimilation (grasping) of knowledge.

As indicated earlier in this chapter, an integration or promoting both recalling and transfer strategies indicates 'meaningful learning' (Mayor, 2002:226). So, 'retention' and 'transfer' are the way to address the problem of forgetting. *Retention* is the ability to recall (*Remember*) at a later time, what was instructed and leaned (Mayor, 2002:226). Transfer is the ability to use learned knowledge to solve new problems during practice or *revision* (Mayer & Wittrock, 1996 cited in Mayor, 2002:226). This means that the role of 'retention' is concerned with 'memory' and 'forgetting' in the learning of school mathematics. Therefore, in school mathematics, retention relates to the kinds and nature of *retention* (memorization) and *revision* strategies that are given to learners as a way to deal with forgetting. Memorisation is a repetition of skills until it can be recalled by heart. It is the binding of information to the memory. Revision is the act of practising or exercising while going through the topics already covered.

Memorisation (retention) and revision strategies work together to produce meaningful learning (Mayor, 2002:226). In terms of the 'forget problem', the role of retention strategies, which are also referred to as memorization strategies, is to promote retention whereas revision strategies work on promoting the transfer of knowledge to new mathematical problems (Mayer, 2002). While retention and revision strategies can be viewed as two separate methods, they are interdependent strategies. Retention and revision strategies play interdependently for meaningful learning, for retention. Even though each has its distinctive unique features, they cannot be conceived of or play in isolation from one another within the context of school mathematics retention. A successful interplay between these two main strategies is crucial for meaningful learning, for retention, a way to deal with 'the forget problem'. Retention and revision strategies work interdependently and have one common role, 'retention'.

The use of advance organizers, just like mnemonics, promotes smooth assimilation by grouping a learning content into brief and manageable portions that can be easily taken up by the memory. Mnemonics has overlaps with drill-and-practice. Their main focus is practising through sequenced repetition. 'Distributed practice' is complementary to massed practice. In other words, they are similar in a way that the sum of the practice is constant.

'Massed practice' and 'distributed practice' require that 12 practice problems are collected/ massed into one session or equally distributed over three sessions for example. On the other hand, with 'overlearning' learners would be given 5 out of these 12 practice problems only for example. So 'massed practice' and 'overlearning' are similar in a way that they are both about similar practice problems. The difference is that 'massed practice' contains a larger sum of practice problems within a single practice set, whereas 'overlearning' consists of a lesser sum of practice problems distributed over two or more practice sessions.

'Distributed practice' requires that exercise problems are not focused on one idea or topic only; however, it is similar to 'massed practice' in the sense that the sum of practice problems are equivalent. 'Distributed practice' is also similar to 'overlearning' in a way that exercise problems are distributed over sessions).

Productive practice has overlaps with distributed practice. Productive practice blends 'spiral revision' and 'deepening mathematical thinking' (DMT). Productive practice also has overlaps with learner-centred approach. According to the researcher, a learner-centred approach is an approach that comprises of teaching methods that shift or alter the focus of instruction or teaching from the teacher to the learners. In brief, the focus of instruction is centred on the learners. 'Spiral revision', has overlaps with distributed practice because of its distributed effect. DMTs have overlaps with the notion of 'problem-solving'. Problem solving is a mechanism of transferring mathematical knowledge or skills to unfamiliar or new situations.

Within a problem-solving setting, mathematics teachers change from the traditional pedagogies where teachers explain and do more (teacher-centred) to pedagogies where learners explore and do more (learner-centred). When learners are encouraged to solve problems, they gain and become competent to use the mathematical thinking process. Exam-driven teaching is similar to productive practice ('spiral revision' and 'deepening mathematical thinking') in the sense that it covers the learning content of a variety of topics since it requires one to teach the content of past examinations and questions hoped to pop up in the forthcoming examination of a particular subject. Spiral revision is similar to distributed practice in a way that they both foster a shuffling method of past learned work.

Even though there are differences between these strategies, they have a common goal which is to maintain previous knowledge and enhance retention for secondary school mathematics (e.g. in Berry III & Ellis, 2005; Julie, 2013; Mayer, 2002). The researcher agrees and concludes that both 'retention' and 'revision' strategies intersect to contribute towards meaningful learning and thus retention.

2.5 TEACHING AND LEARNING THROUGH DIFFERENT RETENTION STRATEGIES - A DISCUSSION.

This section will discuss other researchers' findings and evaluations as well as recommendations related to the different revision and retention strategies. The section will include the researcher's findings and recommendations based on the reviewed literature by providing insights, critical arguments and drawing conclusions. This section will establish an argument n that while there are a variety of strategies in the solution to the "forget problem" which are limitless to learners with different learning styles, some strategies may be more effective compared to others based on how delicately they are used.

2.5.1 Retention (memorization) strategies

Studies indicate that learners taught through mnemonics at all school grade levels demonstrate good comprehension and produce high scores in examinations (DeLashmutt, 2007; Orla, 2009; Pashler &R ohrer, 2007). Ausbel (1967) advocates for the use of advance organizers as guidelines and specifies that they produce 'meaningful learning' in comparison to rote learning (Guthua & Nyabwa, 2008). Learners taught through advance organizers produced high scores at different grade levels in tests and examinations compared to those who didn't (Guthua & Nyabwa, 2008; Luiten, Ames & Ackerson, 1980). If advance organizers are used effectively it would improve achievement in mathematics education (Guthua & Nyabwa, 2008; Luitten, Ames & Ackerson, 1980). The researcher, therefore, is of the view that advance organizers, just like mnemonics, promote smooth assimilation or grasping of ideas and thus meaningful learning, retention and academic achievement.

Memorization is an approved strategy for training (repeated practice) (e.g.H oque[1], 2019:1; Kindt, 2011:137). Thus, memorization cannot at all be abandoned, as some learning material need only be memorised (Hoque[1], 2019). Every slight step adds value to insight, which is a combination of repeated practice and insightful learning (Kindt, 2011:137). Mathematics is learned best through drill-and-practice; it must be practised through sequenced repetition (Thorndike, 1923:52, cited in Ellis & Berry III, 2005:8). While some researchers have promoted and see potential in the revival of drill-and-practice, without a fuller range of instructional strategies, some are suspicious and cautious about it as it would be like 'saying goodbye to skills' (Kindt, 2011:137-138). Thorndike's idea neglects learners' mathematical thinking necessary to apply in situations of problem solving (Wertheimer, 1959, cited in Berry III & Ellis, 2005). Memorization and drill-and-practice do not take the meanings learners make from a learned material and their own experiences that they bring to mathematics into account (Brownell, 1935; Ford & Resnick, 1981; Thayer, 1928, cited in Berry & Ellis III, 2005). 'Drill' on its own leads rather to "routine based on tricks" instead of "routine based on insight" (Van Dormolen, 1975, as cited Kindt, 2011:138).

If a strategy cannot be applied to other appropriate situations then it's a waste of time (Kindt, 2011:138). This implies that if learners cannot apply what they have learned to various unfamiliar or new situations or questions then teaching was wasted. Classroom instruction should foster both recalling and transfer of learned material. For example, if learners can solve problems based on 'Pythagoras' theorem' or trigonometric ratios similar to what they practised (e.g. once these problems are about a simple triangle plain figure) but once these problems are transformed onto a practical kind of problem such as that of sides (or $x$lengths) or angles formed up by a ladder laid against a wall might not be able or struggle to solve this unfamiliar problem. This means learners cannot apply a strategy to a new appropriate situation.

Both memorization and drill-and-practice strategies are rather for improving test scores/performances at the expense of meaningful learning. According to the researcher, drill-and-practice aims at a single idea of recalling because often learners memorize the steps of a specific methodology leading to a correct answer, repeating the moves or steps like a game and lack of understanding of what they are doing. The benefits of memorization and drill-and-practice have often been short-lived. However, the views of Van De Wale et al. (2010:69) suggest a different or new perspective on the drill-and-practice and are of the idea that drill and practice should be considered as two separate terms that demand two different activities and not as one term (see 2.2.1.4). The 'practice' should include problem-based tasks and the 'drill' should involve non-problem-based activities (Van De Wale et al., 2010:69).

Supporters of meaningful or insightful learning are not opposing training (repeated practice) but rather arguing that 'drill' threatens retention of deep understanding or insight (Freudenthal, 19991:114, as cited in Kindt, 2011:138). Skills are important because, even in situations where a calculator could be used, the user should be capable of converting problems into a language that they can enter on a calculator (Kindt, 2011:138). For example, actual skills in dealing with formulas cannot be acquired in the absence of repeated practice (Kindt, 2011:138). The researcher, therefore, suggests that to be meaningful to learners, the skills built through memorization and drill-and-practice should become the building blocks for more meaningful learning. Therefore, like any other memorization strategy, the researcher contends that memorization without other strategies cannot result in meaningful or insightful learning.

2.5.2 Revision strategies

A collection of all similar problems into the same practice set comprises 'massing' and a sum of similar problems for each practice set assures 'overlearning' (Rohrer & Pashler, 2007). Overlearning is a recommended learning strategy. However, empirical literature shows that its benefits to retention might not be long-lived (Rohrer & Taylor, 2006). Overlearning and massed practice slows the teaching pace and limit practice when it comes to content or topics coverage because they are about too much repetition of the same things.

However, overlearning and massed practices are necessary to aid learners to master a particularly challenging content provided repetition of the same type of problem is required. Distributed practice requires that a variety of practice problems are spread over different practice sessions (Rohrer & Taylor, 2007). Many researchers contend that learners should lean more on ‘distributed practices’ and they can mass their learning into a single session precedent to the examinations if they do not need the information or knowledge after the examination or in future (Rohrer & Taylor, 2007).

Becker and Van den Heuvel-Panhuizen (2003) and Burkhardt and Pollak (2006), cited in Julie (2013b), argue that it will always be what is examined that will drive the teaching regardless of several disadvantages accompanying EDT. There is ‘some’ truth in this argument because teaching is guided by the basic learning competencies to be taught as stipulated in the syllabuses upon which learners are supposed to be assessed in tests and high-stakes examinations. However, a weak conception of examination-driven teaching (EDT) is 'teaching to the test' (Julie, 2013). Literature-based on logical arguments regard ‘EDT’ as a strategy that stresses skill-based or remedial teaching rather than critical thinking and thus is not advanced by meaningful teaching (Julie, 2013). This means that learners can do the job well because they have practised but might not have an understanding of the matter. According to the researcher, this means that learners are eventually being tested on routine based on tricks. According to Julie (2013), literature has shown that many disadvantages accompany EDT. The researcher is of the view that even though EDT is a recommended revision strategy, it is, however, not reliable on its own and it puts limitations to practice. This implies that EDT can help improve learners’ skills but it is limited to complete understanding and thus meaningful learning.

Productive practice accompanies ‘spiral revision’ and ‘deepening thinking’ (see Figure 2.5). ‘Productive practice’ means that learners are confronted with ‘deepening thinking’ - like problems. ‘Spiral’ implies that the problems/questions are not focusing on a single topic or idea. ‘Spiral’ is very similar to distributed practice. It promotes variety and speeds up practice with regards to coverage of a variety of topics. ‘Deepening thinking’-like problems are practice problems that demand or provoke a lot of thoughts from the learners, justifying and being accounted to by themselves and others for their answers.

These strategies focus on learners developing skills essential to deal with the high-stakes examination and ‘flexible knowing’ which meaningful teaching advocates (Julie, 2013). Meaningful learning is the kind of learning that involves not only gaining knowledge but also being able to apply knowledge in different new situations (Mayer, 2010). As ‘productive practice’ is more thought-provoking, it is very crucial and most inevitable in the learning of mathematics.

'Productive practice' does not only help learners to refresh their memories but learners are challenged with a variety of problems which would make them be the types of learners who can apply the learned mathematical knowledge to new tasks/problems in high-stakes examinations, during school years and in daily life-enhancing learning as a result. Often, distributed practices produce higher test and examination scores (Rohrer & Taylor, 2006), implying that performance is best when 'distributed practices' or the 'spacing effect' is applied within study time and practice sessions, and senior secondary school learners can rely on it more. No wonder Julie (2011) states that the matter is not necessarily which strategy to use as long as the practice is 'distributed' over 'productive practice'.

However, some studies show that the benefits of some learning strategies might be short-lived. A study done by Pashler and Rohrer (2007), for secondary learners, indicates that the time frame between the latest study session and the test (spacing gap) proved to have a great effect on learners' test scores, with too succinct gaps producing poorer performance than excessively prolonged gaps. Distributed practice was found to benefit long-lasting retention because of its 'spacing effect'. According to an empirical investigation of Rohrer and Taylor (2007), while numerous aspects of practice are valuable and worthy to be studied, mixing or altering the temporary distribution of practice sums and problems or the sequence in which the problems are manipulated or solved showed a large improvement in succeeding test performance. Solely, varying practice time yielded high test performance (Rohrer & Taylor, 2007:482). This shows that spacing study time enhances performance compared to when it is massed (Rohler & Tylor, 2006). Rohler and Tylor conclude that long-lasting retention is promoted by distributed practice but not by overlearning.

Distributed practice was found to produce the greatest test scores compared to massed practice, and this finding or discovery is referred to as the 'spacing effect' (see Baddeley & Longman, 1978; Bloom & Shuell,1981; Brown, Seabrook, & Solity, 2005; Cull, 2000; Fishman, Keller, & Atkinson, 1968, cited in Rohler & Tylor, 2006). Rohler and Tylor (2006) advocate that learners should depend more heavily on distributed practice. Learners will be more skilled in mathematics when they do mathematics and not simply learn about it (Papert, 1972).
This view is supported by Julie (2011), who advocates for more where learners engage with mathematics. This is known for the notion of 'deepening mathematical thinking'. Unfortunately, the majorities of mathematics textbooks have minimal distributed practices and depend more on a format that promotes overlearning and massed practice (Rohler & Tylor, 2006).

This reveals that overlearning is widely promoted even though empirical literature shows that its benefits may be short-lived (Rohler & Tylor, 2006). However, conditions, gaps and consistence matters in terms of the benefits for every strategy and thus all these strategies cannot benefit lasting retention in isolation.

According to the researcher, the benefits of each of these strategies depend on the conditions, gaps and consistency or else neither of them could benefit from long-lasting retention (Pashler & Rohrer, 2007); it should still be noted that some strategies or practice may be more productive than others. It should, however, be pointed out that the benefits of these strategies will vary from one individual learner to another. Different learners will have different learning styles and what works for one group may not be useful to another. There are many ways to accomplish the same end.

The researcher, having explored all the retention and revision strategies in this study, concluded that, just a group of specified memorization strategies along with productive practice, if delicately applied, is needed to achieve meaningful or insightful learning and thus long-lasting retention. This argument is based on the facts that, firstly, retention (memorization) strategies form their own part of instruction and assessment for meaningful learning. Secondly, productive practice is structured around spiral revision and deepening mathematical thinking of which the combined strengths make up for the other revision strategies. Furthermore, the exercises and activities given to learners are aimed at practising all that has already been done or covered in teaching (Julie, 2013a:93-94; Julie, 2011:2). Spiral revision requires learners practising previously learned work through short activities or exercises and the DMTs are focused at pushing the learners' brains to higher orders of thinking levels ("disposition of productive struggle"). Finally, the nature of these activities (productive practice) is more or less the same as the types of questions asked in the National Senior Secondary Certificate Examination (Julie, 2011:2). Indeed, some strategies are more effective than others.

2.6 ROTE LEARNING AND WHY IT TAKES PLACE

Rote learning is a memorization strategy based on repetition (Mayer, 2002:227). Rote learning means learners learn by imitating procedures without clear understanding of procedures and concepts related to the content. The focus on rote learning is based on the view of learning as the acquisition of knowledge where learners seek to accumulate new information to their memory without understanding (Mayer, 1999, cited in Mayer, 2002:227). Rote learning implies memorizing key facts, remembering nearly all the relevant facts and terms but being unable to use the same information to tackle or solve a problem (Mayer, 2002:227). Rote learning means that learners have paid attention to relevant information but do not understand it; hence, they will not be able to use it or transfer this relevant knowledge to new situations (Mayer, 2002:227). Rote learning has overlaps with teacher-centred education where classroom activities are centred on the teacher. This is the direct opposite of meaningful learning.

Noting that rote learning is the opposite of meaningful learning, a description of meaningful learning is necessary for a better understanding of what rote learning is. The focus on 'meaningful learning' is based on the view of learning as the construction of knowledge where learners seek deep insight (Mayer, 2002:227). Meaningful learning overlaps with a learner-centred approach, where classroom activities are centred on the learners. Meaningful learning means the ability to recall all important facts and information, as well as the ability to make sense of these experiences and use the information to solve problems. Meaningful learning's main objectives are to improve recalling and to improve transfer. Recalling demands the learners' ability to remember information and transfer requires their ability to make sense, apply and use the information in unfamiliar situations. Recalling is focused on the past and transfer is focused on the future (Mayer, 2002). Thus, the researcher concludes that meaningful learning focuses on both the present and future, unlike rote learning which is only fixed on the past. Meaningful learning is a purposeful kind of learning that involves not only gaining knowledge but also being able to apply knowledge to different new situations (Mayer, 2002). This view is consistent with that of De Lashmutt (2007), who states that learners are not to be taught mathematics to understand concepts only, but to retain the material as well.

Meaningful learning demands classroom instruction to go far beyond simple representation of accurate knowledge and assessment that requires not much more of the learners than recognising and recalling knowledge (Bransford, Brown & Cocking, 1999; Lambert & McCombs, 1998, cited in Mayer, 2002). Rote learning is the inability to make use of the necessary possessed knowledge to solve a problem (Mayer, 2002). Rote learning takes place based on individual teachers' experiences, circumstances, and settings.

Rote learning can be a result of time constraints. Rote learning can also be a result of teachers not having the necessary opportunities to deepen their mathematical thinking. Rote learning results from traditional teaching practices of teacher explanation and learner passive receptive modes. Rote learning can also occur as a result of the lack of integration of retention and revision strategies. Alternatives to rote learning are meaningful learning, active learning and associative learning.

2.7 SCHOOL MATHEMATICS TEACHING PRACTICES: A VIEW OF SCHOOL MATHEMATICS TEACHING AND THE USE OF RETENTION AND REVISION STRATEGIES BY NAMIBIAN SENIOR SECONDARY SCHOOL MATHEMATICS TEACHERS

The focus of this section is on the process of school mathematics instruction in Namibia related to retention and thus meaningful learning. Firstly, a brief review of the literature on the paradigm shift in school mathematics education teaching and learning is given. Secondly, a description of a view of school mathematics teaching and learning related to the use of retention and revision strategies in Namibia is presented. Lastly, the researcher concludes by providing a concise judgment related to meaningful mathematics education in Namibia.

According to Kilpatrick (1992:1), school mathematics teaching and learning develop over time in aspects that are consonant with fixed assumptions and beliefs about the school mathematics teaching career. Research shows that, in the 1800s, school mathematics teachers were convinced that successful school mathematics teaching is about mathematics teachers showing procedures and learners imitating those procedures afterward (D'Ambrosio, 2006:39). This implies that a school mathematics teacher's role was to dispatch or impart, demonstrate and explain procedures or steps for solving problems in mathematics (Artz, Armour-Thomas & Curcio, 2008:5). Subsequently, learners are supposed to listen attentively and passively to their teachers and repeat the procedures. However, as discussed earlier (See 2.1 and 2.2), the new paradigm is raising awareness that learners should learn meaningful school mathematics through meaningful learning. It is confirmed that reforms grounded in the emerging paradigm of 'meaningful learning' assure a productive change in how learners experience achievement in school mathematics (Berry III & Ellis, 2005:7).

Namibian teachers are familiar with some retention strategies. Some of the retention strategies, such as mnemonics, drill-and-and practice, massed practice, overlearning and 'EDT' are frequently used. Some of the memorization strategies, for example advanced organizers, distributed practice and productive practice (spiral revisions and 'DMTs') are rarely or never used by most of the teachers. However, Namibian mathematics teachers are faced with certain challenges in addressing the 'forget problem'. Revision is one of the commonly used retention strategies in the Namibian senior secondary school mathematics curriculum. It is commonly done through different kinds of informal and formal assessments such as 'classwork', 'homework', 'written tests', 'practical investigations' and 'projects' guided by the Namibian curriculum policy documents such as the Syllabus, Schemes of Work and the National Mathematics Policy Guide (The National Mathematics Subject Policy Guide Grades 5-12, 2008).

These kinds of activities are done for assessment, to see how the learners are doing and to direct the teachers as to in which areas more revision or re-teaching is required. In Namibia, revision in school mathematics is mostly done during a revisit of a topic and at the end of the term work. Mostly, individual teachers do revise by preparing questions that they think would serve best in a particular area of revision found challenging through the learners. They go through past question papers or go through the examiner's report with the learners. The researcher observed these retention practices, having been a teacher as well and a subject head at the school where she is currently working.

According to The National School Mathematics Subject Policy Guide Grades 5-12 (2008), classwork and homework are activities containing questions on the same topic for revision of a lesson/topic. Written 'topic tests' ordinarily should consist of short questions along with more structured questions in connection with the basic competencies stipulated in the syllabus and focused on that particular single topic. 'End-of-Term' tests normally can cover more than one topic, for example, the work for the whole term. Practical investigations are normally based on one topic as well and are aimed at assessing the learners' ability to think and critically argue and reflect independently on their thinking. In this phase of the investigation, learners are expected to reason independently. Projects are much longer tasks/assignments than classwork or homework. It's another type of investigation that puts learners into a position where they should pursue a 'topic' on a deeper level more playfully and creatively. Projects are aimed at assessing learners' ability for problem-solving and application of mathematics to real life, for example, a project involving environmental issues or population/census such as the HIV and AIDS population (The National Mathematics Subject Policy Guide Grades 5-12, 2008). Projects are to be compiled and established on one topic at a time.

While Namibian teachers are familiar with these retention and revision strategies provided in the Namibian senior secondary school mathematics curriculum or the policy documents, there are no effective teacher training programmes or support systems to guide the teachers regarding how to implement them or other effective retention strategies. Teachers are working with minimal support from education officers, seeking ways to develop their classroom practices on their own. Teachers need to explore more strategies and use strategies that promote meaningful learning and thus not only performance but also academic achievement (meaningful learning). As illustrated in 2.5.2, some strategies are long-lasting compared to others. If teachers study and learn more about effective teaching strategies and use them whenever they can, regardless of the policies at hand and the challenges surrounding them, learners would develop a meaningful understanding of mathematics. However, the curriculum practices still need to be amended.

The information (the strategies) above shows that a view of school mathematics assessment in Namibia almost entirely focuses on a single topic at a time. As a result, when learners are confronted with mixed problem types, for example during high-stakes examinations, they are faced with something unfamiliar (Rohler & Tylor, 2007:485). This is because the choice of procedures is not as obvious to the learners during examinations as when they are tested on one topic at a time (Rohler & Tylor, 2007:485). Thus, learners struggle and might fail. This entails that the Namibian school mathematics curriculum and the current subject policy are not fully engaged in promoting meaningful learning. The confinement of the teachers to the curriculum set up could add up to the contributing factors to the 'forget problem' in Namibia. To promote meaningful learning, the Namibian school mathematics curriculum and policy structures should refrain from fixed prescriptions or instructions for classroom practices and lists of criteria for evaluating or measuring learning, to improve school mathematics teaching and school mathematics achievement (Berry III & Ellis, 2005:14).

2.8 CHALLENGES OF TEACHING THROUGH RETENTION STRATEGIES: A VIEW OF NAMIBIAN TEACHERS

The experiences of senior secondary school mathematics teachers are discussed as they attempt to change from more teacher-centred pedagogies towards learner-centred pedagogies (learner exploration of ideas) within an environment of retention. Teacher-centred education refers to the communication or dissemination of information to learners in a learning setting where the teacher has the ultimate authority or responsibility (Mascolo, 2009, as cited in Serin[1], 2018:164). Learner-centred instruction facilitates motivation to learn, establish learning, construct and promote knowledge retention (Collins & O'Brien, 2003, cited in Serin[1], 2018:165). Learner-centred classrooms allow learners to construct their insights from their actions and experiences (Serin[1], 2018:164). Learner-centred education is established on democratic and constructivist principles and, alternatively, teacher-centred education relies on behaviourist theories (Serin[1], 2018:164).

By the above ideas, the researcher seeks to make the following points: learners are not passive 'receivers' of knowledge from the teachers, but active 'constructors' of knowledge (Doer & Lesh 2003:212); Teachers should allow learners to struggle, make possible mistakes and discover what informs the mistakes of the learners (Heibert & Stingler, 1998:3); a learner should, by all means, be given opportunities to make his/her own meanings to make remembering easier (thus, retention and revision strategies).

Some researchers refer to teacher-centred approaches as ‘traditional approaches’ where teachers show or demonstrate and narrate while learners listen passively, or imitate and follow. Learner-centred education suggests that teachers should change from the characters of instructors into the roles of facilitators and guides. Subsequently, the learners would develop their roles as active participants instead of passive imitators and followers (learner-centred education). This requires that a teacher is expected to change how he/she teaches as well as what he/she assesses. Teachers should also attain a deeper and flexible knowledge of subject matter than that needed to follow fixed procedures in manuals, textbooks or lesson plans. In a learner-centred classroom, learners are in charge of learning unlike in teacher-centred environments where teachers are in charge. The teacher’s role is expected to shift to assisting learners in building on their existing knowledge for a deeper understanding rather than following fixed directions provided in textbooks or teachers’ manuals.

Even though some teachers are aware of some strategies that may lead to meaningful learning, such as retention and revision strategies, it remains difficult for teachers to develop mathematical understanding through these strategies. The struggles to promote learning by understanding in school mathematics have been the same as looking for the Holy Grail (Carpenter & Heibert, 1992:65). Thus Carpenter (1992) illustrates that the effort to promote meaningful learning was never and is never going to be easy. Facilitating through strategies and procedures to deepen insight entails a great deal of change for mathematics teachers (Buschman, 2004:305). Hence, there are challenges:

According to Buschman (2004:306), one issue the teachers are experiencing is the fact that their former professional training programmes could not prepare them to facilitate mathematics through a problem-solving oriented approach. One of the challenges, therefore, is that teachers are expected to demonstrate skills to learners whereby neither themselves own nor have seen these demonstrations from their tutors. Time constraints and large numbers of learners are the main challenges for Namibian senior secondary school mathematics teachers. These are mutual concerns for these Namibian senior secondary school mathematics teachers. Fatigue, time and the number of participants play a crucial role in the choice (Steve et al., 2003:19). Apart from time constraints resulting from less time allocations for periods, there is very poor maintenance of the teacher to learner ratio which is supposed to be 1:35 (overcrowded classrooms). Additional time constraints result from excessive administration work and activities that Namibian senior secondary school mathematics teachers feel they are supposed to have their unique designated posts.

According to Robinson (2009):

Tight work schedules and timetables for teachers are not an exemption to the challenges. Because of the overwhelming work load, there is no time for studying or proper collaborative teacher involvement. In most schools, especially public schools, teachers are computer illiterate and have no library facilities in their vicinities. Poor leadership, plus the fact that there is no a body that rewards research in teaching are additional constraints. Unhealthy relationships among colleagues exist in the schools preventing teachers to engage collaboratively. Teachers are hesitant about bringing up new information as the department of education takes their ideas without their acknowledgement. There are fewer systems for teachers' sharing of ideas and no coordination at an organizational level for these.

Too much administrative work for teachers is one of the top aspects constraining teacher research especially in Namibia. Teachers are also struggling with the teaching of extra grades, as well as promotional and non-promotional subjects that the teachers were not trained for. There is also no necessary teacher-support system for these particular extra subjects. Since the teachers are expected to teach and assess these subjects as any other subjects, teachers end up investing so much time in research and preparations to teach these less familiar subjects, instead of planning, working on effective strategies for mathematics lessons presentations, and deepening their mathematical thinking for the improvement of achievement in mathematics.Secondary school teachers feel like there is a contradiction between how in Namibia teachers are not short-listed or recruited on a permanent basis when they apply for posts that are not their area of specializations and how a number of other promotional and non-promotional subjects are imposed on these very same under/overqualified teachers as soon as they get permanently employed through their area of specializations. Teachers feel that, in Namibia, ensuring that the teachers are appropriately appointed or placed matters only when a teacher is in search of a job. Limited time and too much administration work for the Namibian teachers are found to be taking up too much time for teachers' personal professional development.

Budget limitations for professional development of the teachers, lack of funding from the Namibian government to finance the teachers for further studies, lack of provisions of full-time study leave opportunities and lack of effective in-service teacher development programmes were the pressing issues revealed by the Namibian teachers.

2.9 HOW LEARNERS' RETENTION OF MATHEMATICS CAN BE IMPROVED

Knowing mathematics classroom practice means having experience about what mathematics content should be covered or taught, how lessons should be planned and how these lessons should be assessed, based on the content (Kilpatrick et al., 2001:379). This section considers classroom practices and ways of studying retention strategies as ways how mathematics retention of the learners can be improved.

2.9.1 Classroom discourse: the case of mathematics

Recent initiatives in mathematics suggest that communicating about mathematics becomes a paramount focus in mathematics classrooms (Anthony & Walshaw, 2008:516). According to Cockcroft (1982:71), some of the factors that led to outstanding mathematics learning incorporate communication of mathematical ideas and reasoning, thereby indicating the level of understanding and inform teaching, for it is believed that when learners are actively engaged with mathematical ideas, they develop specific competencies. The most important thing is the type of quality mathematics teaching practices that will improve mathematical classroom discourse that can yield appropriate learner competencies through making sense of ideas. On the other hand learners' prior (existing) knowledge is necessary to drive learning in the classroom. Some of the things that teachers can do that might enhance a productive classroom discourse include listening to and observing learners' ideas attentively (Anthony & Walshaw, 2008:517). Basically, to make a change through classroom discourse, learners' cognitive attention is shifted towards making their own meanings of mathematical experiences, instead of restricting their attention to fixed procedures (Anthony & Walshaw, 2008:516). The researcher, therefore, believes that exploratory discussions and learner interactions are necessary components of classroom discourse.

Teachers should listen attentively to learners' mathematical explanations, develop strategies that stimulate mathematical reasoning, ask questions to elicit learners' justifications, and figure out with them to make didactic decisions (Franke & Kazemi, 2001:104). Mathematics teachers should extract learners' mathematical reasoning and prepare for various techniques for problem-solving, as mathematics is not only a set of algorithms or procedures to be emulated (Heibert & Stingler (1998:2). Constructivists acknowledge that knowledge is not to be received passively from the teachers but to be constructed actively by the learners. This construction process can be achieved through learners' engagement by making connections between ideas, forming blueprints, and acquiring new mathematics knowledge based on their existing knowledge by interacting with others (Hwa, Lau & Singh, 2009:307; Novak, 2000:548-549).

Nonetheless, for many teachers, it is a great challenge to involve classroom discourse as a central part of a complete strategy of mathematics instruction and learning. Considering learners' participation and honouring the contributions of the learners in the classroom is one of the teaching strategies applied to arouse classroom discourse. Teachers who promote learner participation, extract learner contributions, facilitate learner interaction and encourage them to respect themselves and one another, as well as their different points of view, represent reliable pedagogical procedures in mathematics (Cobb & Yackel cited in Anthony & Walshaw, 2009:523).

2.9.2 Teaching for understanding: the case of school mathematics

Based on literature, it is evident and important to highlight that learner understanding in the classroom is not necessarily enhanced by more doing or talking from the teacher. Teaching for understanding means to teach learners in a manner that will probe the learners' ability to justify their responses. The learners' ability to solve a certain problem correctly does not certainly indicate understanding (Cockcroft, 1982:72). But if the learners understand a problem, they will be able to give justifications for their responses; it's a way to show whether they understand or not.

Learners' ability to deal with unfamiliar mathematical problems should be flexible and methodical to understand how to think mathematically (Schoenfeld, 1985:12). Mathematical ideas are understood if they form part of a central system with several connections linking chunks of information or various details (Carpenter & Hiebert, 1992:67). So, in mathematics, understanding implies the ability to make connections between concepts, details or strategies with an idea of linking existing knowledge to new mathematical problems (Koehler & Grouws, 1992:67). Therefore, understanding implies the capacity to identify and use mathematical ideas in various situations, part of which is not directly familiar (Cockcroft, 1982:68).According to Hiebert and Wearne (2006:13), one way to assist learners in their efforts to gain understanding is to ensure that mathematics is problematic to them. The aim of allowing mathematics to be difficult for learners is to enable the teachers to avoid doing more of the work for learners in the classroom (Hiebert &Wearne, 2006:7). Such a premise is not consonant with the ideas of Julie (2011), about 'productive practice.' These are the ideas of 'deepening mathematical thinking' ('DMT' in 2.3.2.4). These are environments and activities where learners have a chance to engage with the mathematics and where learners learn that struggling is part of learning mathematics ('disposition of productive struggle') (Julie, 2011).

Deepening mathematical thinking tasks are part of the strategies to address the forget question/problem. Making mathematics difficult for the learners implies allowing learners to 'struggle' to get answers and test their methods (Hiebert &Wearne, 2006:6). Understanding is improved by allowing learners to become curious about a particular topic, figure out and discover how previously learned topics are related or different from one another, and become confident to deal with novel problems (Hiebert &Wearne, 2006:6).

Learning with understanding improves learners' recalling techniques and assists the learners to relate unfamiliar mathematical ideas to their existing knowledge (Artzt et al., 2008:9). Learner understanding is probed by asking learners to justify the strategies they used to get to a solution.

2.9.3 Dispositions and motivations in mathematics learning

Learning is change as an outcome of practice or experience in a rather fairly or constant internal state (Steven et al., 2003:20). Learning entails gaining of knowledge (Mayer, 2002:226). Having been a school mathematics teacher, the researcher observed that in most cases teachers believe that learning and performance are linear and as a result they confuse learners' performance for learning. Learning can take place without a direct connection or link to performance (Steven et al., 2003:20).

Learning and performance (achievement or test scores) may not be growing at the same pace (Burdick, 1991, as cited in Steven et al., 2003:20). By itself, improved performance does not mean learning but rather a sign that learning has taken place (Schmidt 1991 as cited in Steven et al., 2003:20). Performance is more short-lived (more short-term) and draws on or is associated with test scores or grades (Steven et al., 2003:20). Teachers also confuse or mix up learning with achievement. Achievement refers to competency or a person's ability in an area of content (American Psychological Association (APA), 1999 in Algarabel & Dasi, 2001:45). This competence should be an outcome of both non-intellectual and intellectual variables (Algarabel & Dasi, 2001:45). So, achievement is more about reaching or attaining your academic goals or targets, whereas performance is about how well you did. Learning in terms of mathematics or learning any matter related to mathematics assures mathematical learning. Mathematical learning occurs through positive dispositions and motivations (Brahier, 2011:4).

According to Anderson, Bobis, Martin and Way (2011:32), motivation is considered as a driving force for mathematical learning. Disposition incorporates curiosity, interest in the subject, flexibility in the exploration of mathematics and different problem-solving strategies, and valuing mathematics application, perseverance, attitude towards mathematics and confidence in using it (Brahier, 2011:4). Both dispositions and motivation are, hence, related to 'disposition of productive struggle' and the process of 'deepening mathematical thinking' suggested in Julie (2011) and Julie (2013a). Motivated learners possess a sense of potency or self-efficacy that allows them to be successful at a mathematical activity and follow their beliefs. Self-efficacy enhances learners' willingness to engage with mathematics (Brahier, 2011:4).

When teaching mathematics, we should not simply help learners gain mathematical skills; we should also seek to give motivation and promote constructive dispositions towards mathematics learning that will possess lasting effects, from the learners' confidence to learn and do mathematics to their choices of careers (Brahier, 2011:7). Mathematical skills refer to thinking processes revealed at solving various mathematical problems (Egeric & Mihajlovic, 2008:2). 'Skill' is when problems are confronted not only intentionally and adequately but also are dealt with within a reasonable timeframe (Van Dormolen, 1975, as cited in Kindt, 2011:138). 'Skill' is 'routine based on insight' rather than 'routine based on tricks' (Kindt, 2011:138). This was Van Dormolen's definition or view on skill. This depiction is highly consistent with Kindt's views about the favourable introduction of practice (Kindit, 2011:138).

Therefore, mathematical skills can also be referred to as the ability to carry out different mathematical problems. Teachers should consider the motivation level and dispositions of the learners for every lesson preparation and have the development of these effective attributes as one their objectives. The matter of motivation should be in alignment with the lesson's aims and objectives (Artzt et al., 2008:11). Motivation and disposition is advanced by using various facilitation procedures, visual activities, various resources and a variety of assessment strategies.

2.9.4 Assessment in school mathematics

One of the goals of the revised Bloom's Taxonomies of learning described in this chapter is intended to aid educators and teachers to improve the manner they assess learning. The most important educational goals are to promote both *recalling* and *transfer* of knowledge (Mayer, 2002:226). Assessment tasks therefore should integrate cognitive processes for both retention and transfer (Mayer, 2002:232). Mathematical assessment is done to assist mapping or plotting a national procedure that will have a meaning or implications for improvement of mathematics education for a nation (Webb, 1992:663). Another goal of mathematical assessment is to monitor mathematical understanding and skills of the learners for teachers to plan and appropriately guide instruction (Zebarth, 2006:178). Classroom teaching is largely orchestrated and ordered around assessment. Each tool (exercises, activities, tasks and tests) used to test a learner's mathematics performance level should take into account and have as a goal an enhancement of learning with understanding.

Teachers often experience challenges when attempting to switch from conventional assessment practices to new assessment practices that promote understanding (Ziebarth, 2006:178). Despite the challenges in mathematics assessment, if learners are tested or assessed in a way that strengthens methods of learning with understanding, the teachers can in some way address the forget problem and thus enhance achievement in school mathematics. Traditional practices of assessment used to abandon assessment that enhances deep understanding and assess mastery of skill alone. For instance, asking a learner to find the answer to $a = 45 - 15b$ entails recalling a fixed procedure only.

Asking learners to use more than one method to solve the same equation or to provide a real-life practical application or example of the equation's representation will enhance understanding. One other approach for drawing up assessment that enhance deep mathematical understanding start with a situation or a context and compile assessment questions or problems around it. Assessment forms part of teachers' decision-making (Hofmannová, Novotná and Petrová, 2008:24).

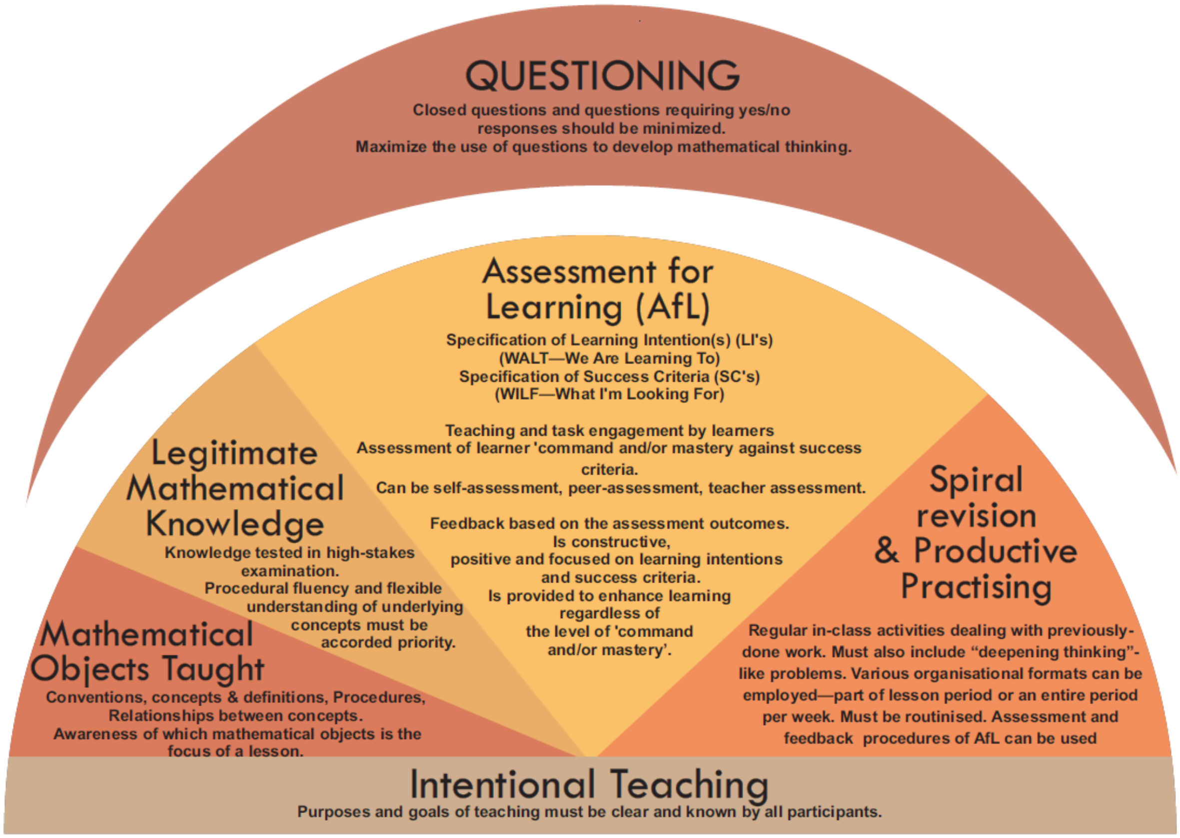


Figure 2.10: A model for intentional teaching of school mathematics.

(*Source*: Julie, C. 2013a Retrieved from http://www.amesa.org.za/AMESA2013/Files/P11.pdf).

First and foremost, the teaching model (figure 2.10) introduces the type of teaching where the learning intentions (LIs) of a part of work are eloquent to both the teacher and the learners. Second, this model of teaching suggests that teachers' questioning should involve questions that provide opportunities for deepening mathematical thinking of learners rather than multiple choices or yes/no questions. Third, the aims and objectives (intentional teaching) should cover the conventions or traditions. These are how mathematical things are written (notations and representations of symbols), mathematical notions and definitions, methods and connections (mostly operationally such as addition, subtraction, division, multiplication and so on) between concepts (commonly theorems) and considering which mathematical item is the centre of the lesson. Fourth, the intentional teaching model suggests that knowledge tested in mathematics high-stakes examination dictates what legitimate mathematical knowledge is (Kvale, 1993, as cited in Julie 2013a:92) and should be the priority for intentional teaching.

Fifth, Assessment for Learning (AfL) should address four issues: all participants should be able to articulate the learning intention; confirmation whether the learning intentions were reached using explicit assessment criteria (the WALT and WILF in the figure); engaging in activities based on the knowledge item of importance for a particular lesson; and in the end, peer, self or teacher assessment based on success criteria (SCs) and feedback based on learning intentions(LIs) and success criteria (SCs). The last component of the model illustrates the productive practice described earlier (see fig. 2.5). The idea of productive practice suggests a procedure of maintaining regular spiral and productive practice routinely. The suggestion is to set aside time regularly to present at least two to three problems on previously learned work to learners. This practice should preferably take at least the first ten minutes of the period time allocation or a whole period once a week (Julie, 2013b:93). That is intentional teaching (Julie 2013a: 93-94). The overall component of the intentional teaching model above is the idea of interrogating or examining to promote mathematical thinking (Julie, C. 2013a:94).

2.9.5 Suggested classroom practices for implementation related to retention & revision

1. Minimising model practice problems

According to Julie (2011), to create time for learners' engagement with mathematics activities, teachers should carefully choose a few model practice problems in the textbook instead of giving all the problems in a particular textbook related to the component they have taught in the lesson. Julie (2011) advises that the remaining exercises should be distributed over 'productive practice' sets as standard questions. For example, if the textbook provides eighteen practice problems on linear inequalities, carefully choose six to nine sums as exercises after the lesson. Spread the rest of the sums over the productive practice, one or two sums at a time.

2. 'Productive practice'

Use ten to fifteen minutes for three to four periods a week for learners to do a 'productive practice' set. Allow learners to practice in groups of not more than three or pairs and get engaged with the problem set. Explain clearly should there be clarifications required, monitor the learners' work and note down particular challenges. Using these notes, draw the learners' attention to certain concerns of their work during the set summary (Julie: 2011:2). For example, if the set involved solving a linear inequality and finally end up having to solve $-3x \geq 9$ and a group gives $x \geq 3$, this learner error has to do with forgetting that when multiplying or dividing both sides by a negative value the sign must flip to avoid making the greater side less than the side which is lesser in reality as the side that is greater gains a bigger negative value.

Or imagine simplifying an expression $2x^3\ y+\ 3xy\ =\ 2x^3\ y+\ 3xy$ but a group provides $2x^3\ y+\ 3xy = 5x^4y^2$. This learner error has to do with the operative curriculum where these literal and numerical symbols are not viewed or seen as variables. The operative curriculum separated monomials/binomials or terms from linear equations. Teacher should write the answer obtained by the particular group on the chalkboard and have the whole class debate whether the answer is correct or wrong. This approach, rather than marking, contributes better to learning. Research indicates that certain teachers have adjusted to the above method. They would put a day per week aside to do 'productive practice' whereby learners do three to four sets (Julie: 201:2-3).

3. Shuffling mathematical practice problems.

Shuffling practice problems entails carrying practice problems from previously learned topics over to tests or practice sets of a new topic. Learners will make sure they don't forget previous learnt topics by practising more as they know previous content will pop up anytime in practice tests. With the 'shuffled format', the choice of procedure is not obvious to learners like it would be when the practice problems are testing only one type of problem. As a result, the learners who get tested on one problem type at a time, later during the examinations that contain different problem types, requiring 'assessing statistical significance', are confronted with a task they had never practised (Rohler & Tylor, 2007: 485). Learners should have the ability and understanding that a certain procedure does not happen by random chance. A lot of different mathematical problems are often superficially similar and this makes it especially challenging to pair problem types with procedures (Rohler & Tylor, 2007: 485).

For example, factoring the left-hand side expression method is required for solving $x^3 - 6x^2 - 5x = 0$, but $x^2 - 5x - 5 = 0$ is solved using the quadratic equation. Both equations require different procedures. This is because *not* all the $ax^2 + bx + c$ (quadratic expressions) are *factorable*. A combination of problem types demands that learners do not only understand how to perform a method but also which method is suitable for each type of problem (Kester, Kirschner & Van Merriënboer, 2004). Learners experience these types of challenges because they are not used to being tested on a mixture of problems covering a variety of problems or even topics at once. Teachers mostly teach one type of problem and asses on the one particular problem at a time; which makes learners' method for solving the problem so obvious. Learners get used to this practice and thus fail when they are faced with various problems during examinations.

4. Adoption of the shuffling format in teaching and textbooks to enhance retention and achievement in school mathematics.

Alternatively, the spacing could be adopted within textbooks, a 'shuffled format' allowing practice problems relating to a given lesson to be distributed or spread throughout the remainder of the textbook (Rohler & Tylor, 2006). According to Rohler & Tylor (2007), the majority of textbooks are made up of practice sets comprised nearly entirely of practice problems relative to the immediately preceding lesson. This apparent ineffectiveness of overlearning and massed practice is troubling as these two strategies are fostered by most textbooks (Rohler & Tylor, 2006). Contrarily, in a few textbooks, practice problems are shuffled systematically so that every practice set collects various practice problems from numerous previous lessons (Rohler & Tylor, 2007: 482). For example, a lesson on graphs of functions can be followed by a practice set with practice problems on other previous topics and only a few of these problems would relate to graphs of functions. Other problems on graphs of functions can be distributed throughout the remaining practice set.

5. Repetition

A lot of repetition on a learning content of concern allows learners to get more familiar with the content. Therefore, repetition contributes to long-lasting retention. Teachers can repeat a lesson as much as possible when necessary. Ordinarily, repetition is similar to when you walk through a previously unfamiliar path/route for many times; you get more familiar every time you walk through it until you no longer need guidance. According to Hoque[1] (2019: 2), every time a human brain learns something new, a connection or relation is made between the neurons in the brain, and the more the learning material is repeated, the stronger the connection gets. That is how human brains think and operate. The "shuffled format" discussed above can also boost repetition.

6. Making learners take the role of teacher.

Assigning learners to teach others as a revision strategy is one effective method to reinforce repetition. Teaching others would require learners to organise the things they have learned for them to be able to teach them to others, which then makes it easier for them to recall better and apply knowledge during mathematics tests and examinations. The learner-teacher would be required to polish up on their skills before they can teach something to others; this will demand that they learn something more than once or more, which will assist in binding the ideas onto the brain (Hoque[1], 2019: 6). When learners explain learned material to others, memories that were fading are reactivated, consolidated and strengthened. This practice not only improves retention but also boosts active learning (Sekeres et al., 2016).

7. Keeping track of information.

Encouraging learners to develop a habit of keeping track of information and paying more attention in class rather than studying or practising at a later stage can be beneficial. Ordinarily, learners who keep track of information pay more attention in class and remember things better compared to those who don't. This is what Hoque[1] (2019:6) calls 'Focus to Remember'. In order for one to retain information, they have to concentrate and pay attention; if not, the information can be forgotten within the next few seconds (Hoque[1], 2019: 6). Hoque[1] (2019:6) suggests that sharing this piece of advice with the learners and encouraging them to work on retaining information can surprise them.

8. The use of technology

In the school mathematics context, digital tools are what are referred to by the term technology (Bay-Williams, Karp & Van De Walle, 2010:111). These tools could be calculators and other handled devices, desktops and laptop computers, collaborative authoring tools, dynamic geometry software, computer algebra systems, podcasts, online digital games, spreadsheets, interactive presentation devices, as well as any available resources such as internet-based resources for use with these tools and devices (Bay-Williams, Karp and Van De Walle, 2010:111). Technology is a necessary tool for both teaching and learning mathematics and all schools must ensure that all their learners gain access to technology (Bay-Williams, Karp & Van De Walle, 2010:111). Technology should not be thought of as an 'extra' added on to the number of things one is trying to execute in the classroom as this is not an efficient approach ((Bay-Williams, Karp & Van De Walle, 2010:111).). Rather, technology should be considered as the main part of one's instructional stock of learning tools (Bay-Williams, Karp & Van De Walle, 2010:111). It can expand the scope of the learning content and can extent the rank of problems that learners are able to solve (Bay-Williams, Karp & Van De Walle, 2010:111). Using technology can also be a fun and a successful method to cement ideas into the brain. Ordinarily, people recall better the things that were presented to them in a creative, attractive or fun way, which technology most often provide.

9. Minimising the use of calculators to encourage deepening mathematical thinking and improve retention

Calculators are the most commonly digital tools used by school learners. Calculators can be used to establish and improve problem-solving concepts, for drill, to enhance attitude and motivation and are commonly or regularly used in society (Bay-Williams, Karp & Van De Walle, 2010:111).

However, calculators can limit learners' understanding if they is used unnecessarily as they can partly do the thinking part on behalf of the learners and thus can deskill the learners. Calculators are used unnecessarily when what they are used for can be conveniently and effectively be done without it. Skills are important because even when a calculator needs to be used the user should be capable of converting problems into a language that they can enter on a calculator (Kindt, 2011). Allowing learners to only use calculators when it is totally necessary could promote a deep understanding of mathematics knowledge. Teachers could as well compile respective practice activities where calculators are allowed and where calculators are not allowed for each topic where possible. For example, you can have your learners thoroughly practice and understand that calculating a percentage which is a multiple of 5 of a total amount or value that is within 1000 does not require a calculator. For example, if $10\% \ of \ N\$960$ is N$96 then 5% $of \ N\$960$ is N$ 48 since 5% is half of 10%.

10. Meaningful learning

Teaching and assessment should demand from the learners cognitive procedures for both *recalling* and *transfer*. Teachers should provide opportunities for flexible understanding by avoiding constrained methods or procedures for obtaining answers. Teach for procedural fluency and flexible knowing (Julie, C. 2013a:93). The researcher believes that if teachers can base their teaching on knowing that mathematics is not just a set of procedures to be explained by teachers and followed by learners, they would be able to come up with strategies for improving their classroom practice to address the problem of forgetting.

2.9.6 Ways of studying retention/revision strategies of the teachers.

2.9.6.1 Pre- and in-service and distance education programmes

Good teachers combined with the methods and practices of teaching are what make a great impact on the students' achievement (Christie at al., 2007). Teachers can only teach using retention strategies if they were trained through the same practices or when they are in networks (collaborations) where retention/revision strategies are discussed and developed, over time. For this reason, positive attitudes and expertise towards mathematics facilitation using retention and revision strategies can be developed, promoted and expanded to mathematics education training programmes.

In-service teachers can also study retention strategies through distance education. Distance education surfaced as a response to the demand to provide opportunities to individuals in the cases where they are unable to partake in face-to-face education (Beldarrain, 2006:139). According to Slimp (2014:21), distance education is a description of efforts by students engaging with the learning process at locations isolated from their instructors, and mostly from fellow students.

The use of distance education around the world employs a broad range of audiovisual and online technologies to overcome the absence of face-to-face contact between students and their lecturers (Baggaley, 2008:39). Distance education does not only provide freedom from constraints of time and space but also offers advanced delivery of multi-media, broadens learning and personalises learning. The other terms for distance education are ‘open learning or distance learning’.

2.9.6.2 Collaboration work and future research

Collaborative work has been researched over numerous scientific disciplines. Collaborative work emerged in the year 1970 (Baker, 2015:1). As distinguished from coordination, collective activity and cooperation, collaboration refers to a co-joined and continued effort towards sharing presentations of the solved problem to develop a ‘joint problem space’ (Baker, 2015:1). Firstly, teacher development activities should provide opportunities for partakers to share ideas and knowledge. The emphasis of collaboration between teachers and educators and/or trainers as well as among the teachers should be given to group work during sessions (Hayes, 1995:260). Collaboration work could involve the types of group work where teachers would share ideas on how they could prepare, teach lessons and compile assessment activities on different topics through retention strategies.

One mechanism in which mathematics teachers can acquire knowledge to become competent to teach for meaningful learning is to associate themselves with competent teachers or educators. Meaningful learning, as discussed earlier in this chapter, entails learners not only acquiring knowledge but also the ability to apply this knowledge to new situations and real life. An integration of retention, of ‘recalling’ and ‘transfer’, assures meaningful learning (Mayer, 2002:227). Collaboration of teachers in this regard will be helpful. It would be a good opportunity for teachers to deepen their thinking on the mathematics. ‘Teaching is a cultural activity’ (Stingler & Hiebert, 1998:2). Like more other cultural activities, teaching skills are acquired through non-formal engagement over a length of time. It’s a skill one acquires through growing up or spending a length of time in a culture instead of formal learning. Individuals who grew up in a certain culture (for example a teaching culture) will have a common imagination of what teaching is. Lastly, it’s a challenge to change various personal beliefs on what accounts for mathematics learning.

Teachers and other educators can learn about retention and revision strategies from one another through collaboration work. In this way, they can create teaching/learning materials, come up with initiatives and run projects towards the development of mathematics teaching through retention and revision strategies. Through these, teachers and educators in Namibia concerned with the improvement of achievement in senior secondary school mathematics can also come together for development and research groups focused on approaches to deal with the forget question.

2.10 CONCLUSION

Except in the cases of diseases or injuries, the human brain does not lose information; humans never forgets things (Hoque[1], 2019:8). Forgetting is rather basically a result of not storing information (Hoque[1], 2019:8). The more the various retention and revision strategies are practised, the more they become more natural and easier (Hoque[1], 2019:8). Generally, it does not matter which implementation approach is used (Julie: 2011). What matters is that the learners are engaged in "productive practice" weekly and it is aligned with the proposed or some sort of teaching strategy. One might observe that the time the learners spend decreases as they get used to a particular way of working (Julie: 2011).

Reviewed literature suggests for change when it comes to the manner that mathematics teachers have been trained over the years. Research advocates for changes in the manner in which learners are taught mathematics. Literature also presents strategies for dealing with traditional ways of teaching. Senior secondary mathematics teachers are encouraged to conform to the reform policy and assure that mathematics is taught through a more 'deepening mathematical thinking' oriented manner. Most importantly, the focus of the mathematics instruction process shouldn't be more on the number of practice problems but on how the subject is taught.

Based on the reviewed literature, it is visible that the individual teacher's knowledge of school mathematics content and personal beliefs about school mathematics teaching led to a teacher's particular way of teaching mathematics. The researcher's interest was to learn or discover the teachers' perceptions and the use of retention and revision strategies in their teaching practice. While valuing that the teachers' individual beliefs about and perspectives are essential to personal practice, the description in this chapter is aimed at helping educators and teachers to develop a broader set of educational objectives that are feasible to bring about both *retention* and *transfer*.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

In the two previous chapters, the background of the study was considered, related literature was reviewed and theoretical conclusions were drawn from the reviewed literature. Chapter 3 provides an insight into the design and methodology used in this research study. The methodology used is best suited to achieving the aim of the study and answering the research questions. The methodology is innovative and thus can shed more light on the topic. This chapter gives an account of the procedures followed in the planning and generation of the data regarding the awareness and usage of retention and revision strategies by senior secondary school mathematics teachers in Oshikoto region in Namibia. The chapter comprises of a lay-out of the main and sub-research questions, aims and objectives, design, paradigm, and data collection procedures of the research. Discussions of the data analysis, delimitation and limitations, the study assumptions, trustworthiness and ethics-related issues are also addressed towards the end of the chapter.

3.2 RESEARCH QUESTIONS

Research questions guide the choices regarding the research design and research methods; research questions aid to connect the literature review to the variety of data to be collected (Bryman, 2007:2). One cannot logically address a problem without some questions to direct and structure the responses (Knobel & Lankshear, 2005:172). Several questions as pointed out in Chapter 1 were formulated in order to achieve the goal of this study. The questions stated below guided the study.

3.2.1 The main research question

How do Namibian senior secondary school mathematics teachers perceive and experience the facilitation of mathematics through retention and revision strategies?

3.2.2 Sub-questions

The study applied an interpretive approach and an inductive reasoning to establish the supplementary questions of the research study.

Inductive reasoning takes or proceeds from specific data to a general case (Connole, 1993:10-11). Inductive reasoning is an approach whereby the researcher reasons from specific observations to a general ideas or principles. The observations may indicate a generalisable idea or pattern which if consecutively tested and confirmed can result to a legitimate idea (Connole, 199310:11). The sub-questions as shown in section 1.4.3 indicated quite a long list so the researcher shortened the list here by grouping the last six bullets as follow: What are implications of findings?

- What do we know about effective teaching retention and revision strategies that can improve learners' retention in senior secondary school Mathematics classrooms?
- What are and why teach retention strategies in senior secondary school Mathematics?
- Are there differences between retention and revision strategies or are they the same?
- What are the implications of the findings?

3.3 RESEARCH AIMS

As stated in Chapter 1, this study aimed to explore the experiences of grade 11 and 12 teachers in the Oshikoto region of Namibian concerning how they help their learners retain school mathematics content. In particular, this study sought to investigate the perceptions as well as the kinds and nature of retention and revision strategies that are given to the learners as a way to deal with forgetting and to encourage the teachers' eagerness to apply these revision and retention strategies in the process. The goal of this study was therefore to investigate the use of retention and revision strategies by grade 11 and 12 teachers and to contribute to how Grades 11-12 Namibian teachers can use these strategies to help their learners deal with the problem of forgetting and retaining mathematics knowledge.

3.4 RESEARCH OBJECTIVES

This study focused on investigating the understanding and teaching of school mathematics by Namibian senior secondary school mathematics teachers through retention and revision strategies. A number of research objectives were developed. This research was established on the following research objectives:

- To determine the views of senior secondary school mathematics teachers on teaching through retention strategies.

- To observe how the Namibian senior secondary school mathematics teachers use/apply retention/revision strategies in their mathematics classrooms.

- To investigate whether there was an improvement in the retention of the learners through pre- and post-tests.
- To observe and discover the opportunities and challenges experienced by the Grade 11 and 12 teachers in addressing the 'forget problem'.
- To conduct research that might inform the Namibian senior secondary school mathematics teachers on the use of different retention strategies and overcome possible challenges.

It is hoped that the outcomes of this study will have implications for collaboration work for educators and teachers in Namibia to work together with fellow teachers, people from the directive offices nationally or even internationally to design learning materials and work on projects that can help with revision and retention.

3.5 RESEARCH DESIGN

A research design depicts an outline or plan that directs and guides or navigates all the processes and activities of research (Yin, 2009:75). The research design refers to a strategic plan or guide that incorporates the different components of the research study. Research designs are flexible guides of the research process. Research designs are systematic blueprints of the research process (Yin, 2009:75). They are similar to a plan used to build a house (Le Grange, 2017). A research design interprets the procedures or processes for conducting the research, including where, from whom, under what conditions, and when the data is to be generated (McMillan & Schumacher, 2001:30). The researcher views research designs as attributes that describe the type of qualitative or type of quantitative research. Research designs comprise the outline for the collection, analysis and interpretation of data. Therefore, this section will establish the different components and procedures that will contribute to the structure of this study. It will go on to explain how these components ought to address the research problem.

A case study design

The researcher aimed to explore Namibian senior secondary school mathematics teachers' experiences of mathematics teaching through revision and retention strategies at a limited number of school contexts within a limited period. A case study was, therefore, found to be one of the suitable genres or type of design for this research, based on Cohen et al. (2007:253). A case study is an exploratory, descriptive and explanatory investigation of a person, group, event or experience (Yin, 2009:41). A case study is an investigation process and empirical study that thoroughly examines a phenomenon within its real-life contexts (Yin, 2009:41). Teachers' experiences were explored, investigated, analysed and reported on from within the real life of schools. A case study can either be a single or multiple case studies (Yin, 1993:5).

The researcher preferred a multiple case study for this study (four cases for each school, and one case for each research subject (teacher). Multiple case studies are used either to predict various findings for anticipated deductions or predict related outcomes of the research study (Yin, 2003), as cited in Gustafsson (2017:3). Consecutively, the researcher can validate or confirm whether the research findings are or not relevant (Eisenhardt, 1991, cited in Gustafsson, 2017:3). A multiple case study was then chosen because evidence generated from multiple cases is considered powerful (combined strengths) and reliable (Baxter & Jack, 2008, as cited in Gustafsson, 2017:3). Another advantage of multiple case studies is that they produce more convincing arguments when ideas are heavily grounded in feasible evidence (Gustafsson 2017:3). This is why, in this study, a qualitative theory was developed and grounded in the data. A grounded qualitative research design was how the data was generated and interpreted from this case study ('grounded' indicating that the data analysis is based or rooted in what the teachers say and do). A grounded theory design was used to generate theory found or established in the data at a broader theoretical level (Creswell, 2012:423).

Furthermore, the choice of the design (a case study design) was supported by Freebody (2004:81) who states that the main aim of case studies is to establish an investigation, where both researchers and educators (teachers) can reflect on specific instances of educational or instructional practice. Case studies aim at one specific point of interest within the instructional or educational process or experience and try to acquire professional and theoretical insight from literature and information directly and indirectly related to that instance (Freebody, 2004:81). Case study methodologists stress that teachers are ever teaching a certain subject matter, to certain learners, in certain places and under settings or circumstances that form teaching and learning processes accordingly (Freebody, 2004:81). The case study therefore explored and addressed the dynamics of the problem of forgetting, specifically retention and revision strategies, in real-life senior secondary school situations. Most of all, the study's choice of design (case study design) was chosen to relate to its choice of paradigm described below.

3.6 THE CHOSEN RESEARCH PARADIGM

The research paradigm was initially invented by Kuhn in the early 1970s (Le Grange, 2004:39; Le Grange, 2017). Kuhn related the term 'paradigm' to the phrase 'normal science' which refers to research that is established on prior empirical achievements approved by a certain community of researchers at a particular period (Kuhn, 1996:10).

Paradigms are distinguished from one another based on different knowledge interests such as: prediction and control; understanding, emancipation, and deconstruction (Beets & Le Grange, 2005:117; Gough, 2008:5 Habermas, 1972; Lather, 1991). Paradigms are also identified or categorised from one another depending on different views or theories of ontology (different views of reality), epistemology (views of knowledge), axiology (different values or ethics of conducting research), and methods (theories or ideas about methods).

The '*knowledge interest*' of the interpretive research paradigm is understanding (understanding of an individual's experiences); its '*ontology*' involves a consideration of various realities based on individual experiences (Le Grange, 2017). The '*epistemology*' of the interpretive paradigm is observer subjectivity, an individual's opinion about their observations (Beets & Le Grange, 2005:117; Gough, 2008:5; Le Grange, 2017). The interpretive research paradigm '*methodology*' is interactional (collaboration) and qualitative (Gough, 2008:5; Le Grange, 2017). According to the researcher, the term paradigm, therefore, refers to the theories of knowledge interests, reality, knowledge, methods, and ethics upon which research communities establish their research frameworks. So, a paradigm is a supporting structure (set of facts or ideas) that serves as a guide for a research study.

This study intended to give explanations of processes, behaviours, and procedures shown by the focus group/participants. The qualitative research approach is best suited to address a problem in which you need to explore to learn more from the participants (Creswell, 2012). This study was established on the knowledge interest that the interpretivist's task is to pay attention to (listen, recognise, create room for the voice or expressions of the participants) and understand (Aryl et al., 2006:462). Due to this knowledge interest and epistemological stance (theory of knowledge) of this study, an interpretive qualitative paradigm underpinned the study. This means that the researcher considered and respected the perspectives of the participants and how they interpret them and hence interpreted exactly what the teachers say and do. Teachers have their unique ways of teaching and doing revisions in their classrooms. There can be overlaps with ways other teachers approach similar mathematics content. The researcher's interest was not to judge the teachers but to explain why they say and do what they do under the given circumstance of teaching in a school as a bureaucracy, governed by time table realities, policy document outlines, assessment regime pressures, working with nominal support from education officers, and searching out on their own to improve on their classroom practices.

According to Le Grange (2017), Kevin Darrheim and Martin Terre Blanche (1999:6) identified the three social science research paradigms: constructionist, positivist, and interpretive. Lather (1992:89) identified the paradigms or methodologies of post-positivist inquiry based on the categories of human interest that emphasize theories of knowledge (Gough, 2008). These are interpretive (understand), positivist (predict), critical (emancipate) and post-structural (deconstruct). As Conole (1993) puts it, an interpretive inquiry is the construction of an understanding of human action.

The researcher believes that a research paradigm is more like a style or platform believed fit through how one will conduct, obtain data for the study, present, or report their study.

Below are some of the advantages of establishing a research project within a special paradigm (Henning et al., 2004:25):

- A paradigm provides a framework or background to the study. It helps the researcher to address the key features of a research design being within the boundaries of a framework.
- A paradigm carries a message fixed within a discipline thus placing research in the discipline in which the researcher is working such as mathematics education.
- Paradigms hold studies within specific literature, reciprocating the study and the literature.
- Research situated within a particular paradigm leads to a framework of a study’s key concepts.
- Paradigms enable the researcher to make assumptions about the interrelatedness of things.

The significance of the interpretive paradigm is that it enables the researcher to understand the participants’ views and make sense of them (Aryl et al, 2006:462). The researcher positioned the study within this paradigm because this study was aimed at exploring the ideas and experiences of the mathematics teachers concerning their mathematics facilitation through revision and retention strategies and constructing meanings from their experiences. Using interpretive lenses is an establishment of an understanding of human actions (Conole, 1993). This implies that the purpose of using the interpretive view is to understand the world of others. Through this paradigm, a case study design enabled the researcher to analyse and understand the different cases of teachers within different contexts (Cohen et al., 2007; 85). The chosen paradigm guided the researcher, in philosophical assumptions, in choosing data collection tools and methods.

3.7 DATA COLLECTION METHODS

The data-construction techniques employed in this research study are discussed by considering data production, sampling procedures and analysis of data.

3.7.1 Data generation

Research data are ‘pieces of information found at a site that are gathered logically to provide evidence from which statements and clarifications intended to enhance knowledge and understanding regarding a research question or problem are established’ (Knobel & Lankshear, 2005:172). Research data can, therefore, be defined as information gathered or generated for a reason of investigation to systematically harvest authentic research conclusions, outcomes or answers to your research questions. However, data should not be regarded as that which is there to pick up but comparatively what the researcher investigate, produces and notes (David and Sutton, 2004:27). The choice of questions and the goals that drive the study will aid the qualitative researcher to regulate what counts as data for the study.

The most valuable aspect of a case study data production is the use of multiple data sources (interviews, questionnaires, observations and learner’s transcripts) of evidence that intersects on the same category of affairs or the same kinds of ideas (Yin, 1993:32). The data constituting a case study involves interviews, questionnaires, transcripts and observations/field notes (Cousin, 2005, cited in Gustafsson, 2017:2). The researcher was pursuing to investigate the knowledge and experiences of Namibian teachers who taught mathematics using retention strategies. Instruments were selected to produce data that would narrate the experiences of the teacher in the best possible way. Accordingly, the researcher made use of multiple data-collection procedures. This enabled the researcher to analyse cases from different angles (triangulation), for multiple data generation methods to provide ideas in context or additional details, hence producing rich data for the analysis. The researcher, therefore, conducted face-to-face semi-structured interviews, class observations, made notes and gave teachers the opportunity to complete semi-structured and unstructured questionnaires based on their retention strategies experiences.

The researcher was seeking to explore how teachers perceived and how they were using revision and retention strategies, and simultaneously evaluate whether there was an improvement in the retention of the learners who were exposed to more explicit retention strategies compared to those who were not. Pre- and post-evaluations were, therefore, required, to see whether the retention and revision strategies work or not. The qualitative approach relies on general observations and interviews to avoid restriction of participants’ views by the researcher’s perspectives (Creswell, 2012: 212). Audios recorded during the interviews were just used as a back-up for later in case the investigator needed to look back at what the teachers said during the face-to-face semi-structured interviews. However, a case study is not recognised by its data sources but identified as a good way to describe a case and to explore a context in order to know it (Cousin, 2005, cited in Gustafsson, 2017:2).

3.7.1.1 Sampling

Ten senior secondary school mathematics teachers from two urban schools in Oshikoto region of Namibia were purposefully and conveniently chosen through ‘purposive sampling’. The choice of urban schools was purposive in the sense that schools in urban areas are most likely to be better equipped in terms of teaching and learning resources, to obtain a more realistic answer to the research question. Purposive sampling is the idea that the sites and participants that are selected are those that are ‘information-rich’ (Creswell, 2012:206). This implies that participants and sites are identified based on the places and people that are believed to help us answer our research questions in the best possible way. Others define purposeful sampling as a sampling strategy where the researcher intentionally aims at people and places that are considered to be reliable for the study (Kombo & Tromp, 2006:82). The participants took part voluntarily based on approved ethical research standards.

Ten (10) Grade 11 & 12 teachers from two (2) different senior secondary schools from Namibia were interviewed. During the interviews, notes were taken. Audiotapes were also used to record participants’ responses; so that spoken data could be revisited as much as possible whenever desired (Knobel & Lankshear, 2005:173). After the interviews, four (4), (two grade 11 and two grade 12) teachers from each of the two schools, were chosen for observation. The selection was based on the teachers’ responses to retention and revision strategies. The number of years of experiences was also considered during the selection of the participants. Teachers with more years of teaching experience as well as those with few years of experience as possible were selected to test whether teaching experience determined how teachers taught through retention strategies. The selection was finally based on the teachers’ interest in the research topic and willingness to partake in the study, to share their experiences and for personal professional growth.

Cases are chosen because they manifest a point in question and are unique, not just as a representative or model (McMillan &Schumacher, 2001:37). Being secondary school teachers who taught mathematics in the preferred grades (Grades 11 & 12); the selected teachers were therefore expected to be informational about the retention and revision strategies they use. Convenience also played a part in the selection of the schools. The selected schools were close to each other and were also close to where the researcher stayed and worked during the time of the study. This accommodated the researcher’s budget and made it easy for the researcher to return to and seek clarification from the participants should that have been required. The researcher is also familiar with the environment and some of the teachers and was hopeful that the teachers would not be sceptical to share their expertise.

3.7.1.2 Semi-structured face-to-face interviews

Babbie (2017: 491) describes interviews as a data-gathering chance meeting where one individual (an interviewer) enquires from another (an interviewee). One-on-one interviews are a data-gathering process where the interviewer asks questions and records responses from only one study participant at a time (Creswell, 2012:218). It is a prepared, pre-organised communication between two or more people, whereby one person is in charge of asking questions relevant to a special formal topic of interest while the other/s is/are in charge of giving answers to these questions (Knobel & Lankshear, 2005:198). An interview allows both the interviewee and interviewer to discuss their understanding of their world from their points of view (Cohen et al., 200:267). The researcher concluded that an interview should be considered as a dialogue where two or more people (interviewers and interviewee/s) obtain views from one another based on a set of questions from the interviewer. Qualitative interviews begin with the belief that the views of others are worthwhile (Brayda & Boyce, 2014:319). The interview approach is determined after the questions are determined (Brayda & Boyce, 2014:320). Qualitative semi-structured interviews with different teachers were used as one of the methods to gather data.

The interviews were the first of the three phases of the data collection process. The interviews were conducted at different venues and times so the researcher arranged and communicated details about the purpose, informed consent, place, date, time and duration to all the participants. The researcher compiled all the questions that were asked as an interview guide (Appendix 6) and took the role as interviewer. Moreover, the researcher retained the same conduct for each participant during the respective interviews such as asking the same questions in the same order for each participant. Lastly, the researcher was a good listener and a learner (more 'interested' than 'interesting') without holding the researcher's self-reported opinions, considering non-verbal reactions, leading a systematic conversation, constituting a conducive environment and welcoming the participants' critical opinions (Babbie, 2017; Brinkmann & Kvale, 2009; Neuman, 2011; Seidman, 2013).

An interview schedule was compiled by the researcher with the selected teachers during the time of conducting the study based on the teachers' timetables so that the teachers are interviewed during their off-periods to generate data. The researcher made all the necessary arrangements and interviewed the respondents at their respective schools subsequently. The respondents were motivated to share their understanding or interpretations of the interview questions. The researcher did not necessarily pose follow-up questions on the participants' answers unless in the cases where a high degree of clarity on the responses was required. The schedule accommodated the interviewees' queries about the interview questions as well as the researcher's probes on contributions made. The interviews took between 35 minutes to an hour each.

The researcher took notes during all the interviews. Creswell (2012:218) suggests that notes should be taken during interviews, as notes can be used in situations when a recording instrument fails. Verbal data should be documented in a durable form that can be revisited as much as desired (Knobel & Lankshear, 2005: 173). Audiotapes during interviews were only recorded for whenever review was necessary. Researchers should take adequate notes to later support the structural and analytic demands of the study (Yin, 2009:157). All the interviews were transcribed verbatim by the researcher. Pseudonyms were used to guarantee that confidentiality is assured as per informed consent. The main aim of transcription is to quote and present in black and white the absolute sound strands of words as well as any non-verbal behaviour (Kowal & O'Connel, 2004: 249).

Even though there are various disadvantages in using interviews, the researcher chose to use semi-structured face-to-face interviews, because they provide valuable information and allow the participants to explain elaborated individual responses (Creswell, 2012:218). Typically interviews allow the researcher an extended platform to collect information from respondents. Interviews granted the researcher an opportunity to explore the experiences of the teachers regarding retention strategies. The interview also dealt with a brief overview of the teachers regarding their background and experiences on retention. Furthermore; the researcher has more control over the kinds of received information, can use probes to eliminate any ambiguities and interviews supply only information sieved through the interviewer's perspectives as the researcher sums up the participants' views (Creswell, 2012: 218).

According to Creswell (2012:218), information from interviews can be deceitful, influenced by the researcher's presence, and ambiguous. There could also be other shortcomings such as unavailability of equipment, the need for preparation of equipment for recording and transcribing in advance, handling of participants' emotions, and the need to use icebreakers as a way to encourage respondents to speak (Creswell, 2012: 218). Face-to-face interviews alone cannot capture sufficient information regarding participants' views and feelings (Knobel & Lankshear, 2005: 173). Thus, other forms of data collection such as questionnaires and classroom observations were also used to support data. The semi-structured interviews were used to get a combined strength of both sets of data generated (from interviews/questionnaires and classroom observations) on how Namibian teachers use retention and revision strategies in their teaching. Hence, triangulation was required to validate information obtained from the interviewees.

3.7.1.3 Classroom observations

Ordinarily, observation comprises of an intentional and a thoroughly outlined investigation of what is happening, including the place and time when something is happening and those involved (Knobel & Lankshear, 2005:175). Observation is a method of collecting unstructured first-hand data by studying places and people at a site of research (Creswell, 2012:213).

An observer can play the role of a 'participant observer' or a 'non-participant observer' (Creswell, 2012: 214). Nieuwenhuis (2007:83) describes observation as an orderly method of recording discernible impressions of participants, phenomena, and developments without interrogating them. According to Creswell (2012: 214), it is advantageous to switch observational roles when necessary; however, it is more common to arrive at a site as a non-participant observer and change roles after a relationship is advanced. Creswell (2012: 214) further adds that switching between roles allows the researcher to be involved both objectively and subjectively.

The advantages of observation include a chance to note information as it takes place and to study individuals who have difficulty in expressing themselves verbally (Creswell, 2012: 213-2014). This means that the researcher gathers live data (Cohen et al., 2007:397). According to Nachmias and Nachmias (1996:206), another advantage is that the researcher will collect first-hand information and this will prevent contamination of any factors or circumstances standing between the researcher and the research subjects. Moreover, observations allow the researcher to confirm verbal reports by matching them with real behaviour (Nachmias & Nachmias, 1996:207). This implies that observations provide an opportunity for the researcher to detect any contradictions, should there be, between what the individual teachers said in interviews and questionnaires, and their practice.

Scheduling, record keeping and inference are part of the main aspects that establish observations (Nachmias & Nachmias, 1996:209). It is impractical for the researcher to make a limitless number of observations, to observe the participant teachers at any time, neither to be in all the participant teachers' classrooms at the same time, so the researcher decided on the number of observations, and when and where to observe, based on the individual teachers' teaching time tables. The research programme did not in any way interfere with the normal teaching and learning process. The researcher, therefore, adopted the time-sampling approach. The time-sampling approach refers to a method of choosing observation units at particular moments (Nachmias & Nachmias, 1996:207). Using the participant teachers' teaching timetables, the researcher created a timesheet indicating the venues and times were the eight teachers (four per school) were visited and observed while using different retention strategies in their mathematics lessons. The researcher did class visits and observed every teacher in their classrooms. The observation period was 6 weeks. Each teacher was observed for three to four consecutive weeks during their mathematics periods on their personal school timetables. Observations lasted between 40-45 minutes for each lesson. Each lesson was marked either School A or School B and Day 1, 2, 3, 4 and 5 for Week 1, 2, 3 and 4, for every pseudonymous teacher's name.

Immediately after the selection of research subjects for observation (beginning of week 1), both classes were pre-evaluated by giving the same pre-test and then both teachers of the same grade levels were allowed to teach the same topic. The researcher compiled the pre- and post-tests for particular teachers. The researcher, therefore, became an active participant observer. The activities (assessments) were part of the curriculum (teachers' schemes of work and syllabi were used). It was not something that was developed by the researcher for the research. As alluded to before, the research program did not in any way interfere with the normal teaching and learning programme at the school. The topics taught and assessments done were part of the curriculum and schemes of work. The researcher needed the learners to take the tests seriously as part of their assessment, and therefore made an effort to indicate to the learners that the tests were not used for study purposes only. Some learners wrote only one or two of the three tests. As a result, the researcher considered the learners who wrote both the three tests for analysis.

During observations, teachers who seemed to apply more explicit retention and revision strategies were purposefully and intentionally identified. It is possible that all teachers will have some strategies but impossible that they will all be the same, nor equally explicit. Some learners were more likely to be exposed to more explicit strategies compared to others. The researcher again later in the process switched from a non-participant to a participant-observer by sharing some retention and revision strategies the researcher finds most effective based on the reviewed literature with some of the teachers, who should then apply it themselves with their learners. This was done with the participants who showed more explicit retention and revision strategies only because the researcher needed to use them as a control. The researcher was seeking to have a group of learners who were exposed to more explicit retention and revision strategies than other groups. Identical post-tests on the same topics were then given to both classes after the conclusion of the topic at the end of week 2.

Additional delayed post-tests were given after learners had been exposed to completely new topics at the end of week 4. Because of time, to leave a reasonable gap between the post-test and the delayed test, the learners were tested on topics taught prior to the tests. Results were compared to find out whether the learners retained more compared to the learners who were not exposed to explicit or unambiguous retention strategies. Learners' transcripts were collected and marked by the researcher during the time of the study. Data was generated from class observation notes and copies of learners' tasks (transcripts).

To guarantee the participants' anonymity, the whole observation process was carried out under pseudonyms. This means that pseudonyms were substituted for their proper names. Lessons were marked as Day 1, 2, 3, 4 and 5 for Lesson 1 or Lesson 2 and so on. Each teacher was observed for six weeks, pre- and post-tests inclusive. All the teachers were well informed in advance of the time they would be visited in their classrooms. The researcher was oriented around the school by the school principal who was also a mathematics teacher (School A) and the head of the department (School B).

During the class visits, the researcher completed an observation sheet (see Appendix 7). These observation sheets contained observed details about the specific retention and revision strategies used by the respective teachers and how they were used. The observation sheets comprised of observation checklist presenting the different recognised retention and revision strategies and further comments. During the classroom visits, the researcher also took notes of important points about retention strategies that could supplement the observation sheets. For each class observation, a reflection by the researcher and the teacher was completed subsequently.

The session for reflection allowed the teachers that used more explicit revision and retention strategies to consider and answer to the questions below:

- What ‘retention’ strategies have you used in this lesson?
- What ‘revision’ strategies have you used in this lesson?
- What form of assessment did you use during this lesson?
- How did the learners do during this task?
- Do you think there could be better techniques you could have applied to address the lesson that you think could have helped learners to perform more than they did?
- If yes, how could you have done it better?

The reflection session gave the teacher who did not use more explicit revision and retention strategies the opportunity to respond to the following questions:

- Which type of assessment did you use during this lesson?
- How did the learners perform during the assessment?
- Do you think there could be ways or techniques you could have applied to address the lesson that you think could have assisted the learners to perform better than how they did in this specific task?
- If yes, what do you think could have assisted the learners to achieve more than they did?

For the teachers who used more explicit strategies, depending on the responses of the teachers to the above questions, the researcher provided the necessary support. For safekeeping, after every session, the researcher always filed the observation sheets. For enhancement of the validity of the instrument, the components comprised in the observation sheets were reviewed with the study supervisor. Another important aspect of observation is the extent to which the observer can infer. This means that the observer can make inferences out of an action or behaviour observed as to whether or not an action illustrates a particular variable (Nachmias & Nachmias, 1996:211). The researcher was certain and self-assured of any behaviour that comprised a retention or revision strategy. Observations should be systematic (Nieuwenhuise, 2007:83). This helped the researcher to pay special attention to those areas of behaviour identified by the research specific questions and objectives.

The researcher observed the selected teachers' teaching mathematics in their classrooms. According to (Creswell, 2012: 213) observation has certain limitations, which the researcher, however, took into consideration as follows:

- Observers may be restricted to sites and circumstances they get access to. The researcher tried as much as possible to select the sites and circumstances that were information-rich.
- There could be possible difficulty to develop rapport in the selected sites and awkwardness of being a foreigner. The researcher was familiar with some of the teachers at the selected sites. The researcher also started by getting to know the participant teachers first before becoming a participant observer.
- Possibility of potential deception by those observed. The nature of the research provided no room for deception by the teachers as the main idea was to see their best ability to use retention and revision strategies and see if there was an improvement in retention through the learners.
- Our senses cannot operate in isolation from our past experiences. Hence our past experiences have an influence on what we observe and the inferences we attach or link to what is observed. Lesson observations form part of my everyday responsibilities as the Mathematics and Science Subject Head. Thus, the researcher had acquired assurance to conduct classroom observations uninfluenced by her past experiences.

In this study, observations were done to observe how the teachers were using retention strategies while teaching mathematics. Observations were also used as a form of evaluation to see whether there was an improvement in the learners' retention compared to those who were not exposed to retention strategies.Thus, the pre- and post-tests were used during classroom observations. Class observations were also done to verify whether teachers' verbal reports corresponded with their practice in their classrooms in order to validate some of the information gathered from interviews and questionnaires. In addition, multiple data collection methods were used. For these reasons, classroom observations were chosen as one of the data collecting tools.

3.7.1.4 Questionnaires (Appendixes 8-10)

One of the various forms in which data can be obtained from a research participant is a questionnaire. Questionnaires are written communication that constitute of questions and other matters designed to seek information necessary for an investigation (Babbie, 2017:494). According to McMillan and Schumacher (2001:257), questionnaires are cost-effective; they provide identical questions to all research participants, and aid the researcher in guaranteeing anonymity. Questionnaires are mainly used in surveys, field research, experiments and other forms of observation (Babbie, 2017:494).

Qualitative structured and non-structured questionnaires were used as supplements for analysis, to explore and learn the teachers' perceptions and experiences. Questionnaires are commonly electronic or manual. Questionnaires are used to collect first-hand data on a particular subject or concern, and they are good for discovering self-reported beliefs of a particular group of people. Two teachers piloted the questionnaires in this particular study.

Questionnaires were the last data-collection tools used. This was done so that the questionnaire content may not have any influence or cause any possible potential deception from the participant teachers who were interviewed and observed. The researcher decided on the times and venues for piloting and completion of the questionnaires by the pair of teachers. Two teachers from a different region completed the questionnaires at the same time. The questionnaires were drawn up and conducted by the researcher.

The theoretical framework reviewed in chapter 2 informed the construction of the questionnaire questions. The questionnaire comprised of two respective parts, namely questionnaire 1 (Appendix 8), questionnaire 2 (Appendix 9), and questionnaire 3 (Appendix 10). Questionnaire 1 consisted of unstructured questions and questionnaire 2 and 3 were semi-structured. Both questionnaires included questions that required the teachers to express themselves regarding their experiences on revision and retention strategies. The researcher recorded all the participants' responses to structured questions and discussed responses to the unstructured questions as indicated in 4.4.3 in Chapter 4.

As qualitative data was gathered by the use of structured and semi-structured questionnaires, like unstructured and semi-structured interviews, questionnaires allow participants to express themselves unconstrained by previous research findings or researchers' self-reported views (Creswell, 2012:218). The questions on the semi-structured questionnaire were used to assist the researcher in finding out what the teachers learned from the intervention and figuring out the specific retention and revision strategies Namibian teachers' use. These questions provided an opportunity for the researcher to find out exactly the extent to which Namibian teachers can relate to retention as well as revision strategies used in senior secondary school mathematics. In a way, the semi-structured questionnaires were also used to provoke teachers to try to find ways of exploring or even studying retention and revision strategies. In the process, these questions also provided a platform for the researcher to learn more and new information and exchange ideas about retention strategies with the participants who could have more experience.

The main limitation when it comes to questionnaires is the 'socially desirability effect'. The respondents may give socially appealing answers which may not be their genuine opinions. This is why the other forms of data-generation were used (Triangulation).

The return of the questionnaires was 100% since teachers completed the questionnaires at the same times and places, and were requested to hand to hand it in upon completion for each school. The questions investigated the aspects of school mathematics teaching and learning using revision and retention strategies. The questionnaires involved both open-ended and semi-structured questions. This allowed the participants to express their views in their own words, thus helping the participants to feel unconstrained and have a sense of ownership or control over their responses. Ambiguities were eliminated during the piloting process. Questionnaires were gathered and retained. These were hoped to be 'information-rich'. Then all the sheets were analysed.

Questionnaires were piloted with two teachers, who were non-participants and from a different region. They were not part of the participant schools. The purpose of piloting the questionnaires was to assure the accuracy of the questionnaire and to make sure that the participant teachers would be able to understand all the questions clearly. Particularly, piloting questionnaires serves to monitor clarity regarding instructions, the questionnaire items, and layout as to eliminate any possible ambiguities or problems in phrasing. Piloting of questionnaires was also done to determine the time that was necessary to complete them. Piloting expanded the internal validity of the questionnaire. According to McMillan and Schumacher (2001:407), external validity implies the degree to which outcomes can be utilised in a different context. Case studies cannot be generalised because case studies are context-specific. Questionnaires were gathered and retained. The questionnaire took the two teachers about one hour and 30 minutes.

Below is the feedback provided by the pilot participants and were incorporated.

- Question 3 from the semi-structured questionnaire was rephrased to be a little more succinct.

3.7.2 Analysis

According to Bogdan and Biklen (2007), data analysis is a logical procedure of sifting and classifying all the information acquired from all the data collection sources used in the study to enhance understanding of data to allow the presentation of the findings. This depiction is consistent with the idea that data analysis is a process of systematising pieces of data, identifying their key aspects or features and making sense of them (Lankshear & Knobel, 2005:266). In data analysis, the researchers sum up what they have heard or seen in aspects of common words, phrases, and themes that benefit the researchers' comprehension and interpretation of the developing data. The researcher treated all the participant's feedbacks with utmost respect. As recommended by Miles and Huberman (1994:50), data analysis was considered upon commencement of the data collection process. The data analysis was, therefore, a continuous process.

As stated earlier, the study was conducted at two different schools and comprised of four multiple cases for each school. Observational and narrative data was produced through different techniques, namely face-to-face-interviews, questionnaires, and observations. In agreement with Cohen et al. (2007:461), there is no sole accurate means or procedure to present and analyse qualitative data. Constant analysis method formed the basis for data analysis in this study.

3.7.2.1 Content analysis

An interpretation of content (what is contained) in a communication (message) is what is referred to as content analysis. It is simply the analysis of what is said, recorded or written. Content analysis is a research approach of analysing verbal, written or visual material (communication) for a purpose of identifying specified aspects of the material (Ary et al., 2006:457; Cole, 1988). This research method is used in quantitative, qualitative and mixed methods research (Parveen & Showkat, 2017; Marsh & White, 2006). Through its nature of systematic categorisation procedure which entails coding and identifying patterns or themes, content analysis is a research approach for the subjective analysis of the text-data or content (Parveen & Showkat 2017). From the data generation methods employed in this study, data were analysed by applying the qualitative content analysis through cautious examination and constant comparison of data. As discussed in Chapter 1, the researcher integrated the constant comparative method and the theoretical sampling process to obtain grounded theory (See1.6.2 & 1.6.2).

3.7.2.2 Constant Comparative Method

Analysis of the qualitative data was done in terms of a constant comparative method (Corbin & Strauss, 2008; Glaser & Strauss, 1967; Maykut & Morehouse, 1994). This is a continuous comparison procedure whereby, after identifying units and producing themes (themes and emerging sub-themes) will be coded; finally, simplification of data will be done through data reduction, then short summaries and conclusion from emerging themes will produce new findings (Maykut & Morehouse, 1994). The constant comparative method is an inductive process of data coding used for classifying and comparing data for analysis purposes.

The constant comparative method enabled the researcher to collect, analyse and *continuously compare* each unit of data systematically, to produce or generate a clear and *integrated* grounded theory about how Namibian Mathematics teachers perceive and use retention and revision strategies in their classrooms as well as the implications of findings. A coding system was used because codes allow and speed up the process of analysis (Huberman & Miles, 1994: 65). Research has indicated that the constant comparative strategy is an ideal data analysis tool for investigators using qualitative or mixed methods research (Corbin & Strauss, 2008; Glaser & Strauss, 1967; Maykut & Morehouse, 1994).

3.7.2.3 A grounded theory design

A grounded theory design is a coherent qualitative methodology used to generate a theory that describes at an outspread abstract level, a procedure, activity or interplay about an important topic (Creswell, 2012:423). The grounded theory method is used to produce a theory established in the data generated at a broad theoretical level (Creswell, 2012:423). It is suitable when exploring the everyday experiences of different people to advance a theory (Creswell, 2012:20). Grounded theory enables one to generate an extensive theory about a qualitative phenomenon found in the data (Creswell, 2012: 422). A qualitative grounded theory research approach/design was used as a way in which the data was collected and analysed from this case study. In the qualitative design of grounded theory, the researcher uses various levels of gathering, clarifying and classifying the data (Corbin & Strauss, 2008; Kolbs, 2012:1). The key difference between grounded theory and other approaches is the focus on theory development (Denzil & Lincoln, 2005). Constant comparisons and application of theoretical sampling are essential methods used to develop a grounded theory (Creswell, 2007; Corbin & Strauss, 2008; Locke, 1996; Tylor & Bogdan, 1998).

3.7.2.4 Theoretical Sampling

In qualitative research, the theoretical sampling process integrated with the constant comparative method stated above is an important technique used by researchers to bring about grounded theory (Glaser & Strauss, 1967). Theoretical sampling is a process of identifying and making use of new cases to obtain new understanding or to extend and clarify or refine ideas or concepts (Bogdan & Tylor, 1998). Theoretical sampling is a data gathering and analysis process used to further develop a grounded qualitative theory. In this study, initially, four cases were proposed for classroom observation, but at a later stage, four more cases were selected to develop a combined strength of a grounded qualitative theory. Previous studies have proven that theoretical sampling is often used in association with the three coding levels by Strauss and Corbin (2008) (See 3.7.2.5 below).

3.7.2.5 Coding

According to Corbin and Strauss (2008), coding refers to the system of analysing data. There are three stages of analysis involved in coding: open coding, axial coding, and selective coding in order to collect a full view of the information collected during the data gathering process (Corbin & Strauss, 2008). The first stage (open coding) involves comparing to identify different categories or units, characteristics or features, and aspects among and within the data (Corbin & Strauss, 2008). The second level (axial coding) is about comparing to make connections among categories, deductively and inductively relating subcategories to a particular category (Corbin & Strauss, 2008).

The final level comprises identification, selection and logically making connections among the major categories, justifying these relationships and similarities as well as completing categories that require further development (Corbin & Strauss, 2008). Ideas and interrelations established during the coding process direct the theoretical sampling process. This is what is referred to as the ‘Constant Comparative Method’.

3.7.2.5. A convergent design

Even though this study largely used a qualitative approach, there was a use of a mixed methods research, though limited. A mixed method is a method of gathering and analysing both qualitative and quantitative data (marks/results from pre- and post-tests). A convergent design of the quantitative data was employed to merge the pre/post-test results in the qualitative data. This is a kind of mixed methods research where the researcher gathers both quantitative and qualitative data, examines the two sets of data and links results. Mixed methods research is an approach to research whereby the investigator gathers and integrates both quantitative and qualitative data and then applies the joined strengths of both data sets to draw and obtain interpretations (Cresswell, 2015:2). The aim is to acquire an in-depth understanding of a problem that had both qualitative and quantitative dimensions. This helps to get a more thorough view of a problem that cannot be achieved by either a qualitative or quantitative study alone. In this study, a thematic analysis of qualitative data and statistical analysis of quantitative data (pre- and post-tests) were used (Cresswell, 2015:2). The pre- and post-tests (statistics/marks) were not the study’s unit of analysis, but the researcher went the extra mile to see whether retention and revision strategies work or not. In other words, to show why the researcher expected the teachers to use retention and revision strategies or even why this study or research was relevant.

3.7.2.6 Data reduction

Huberman and Miles (1994) describe data reduction as a method that involves choosing, simplifying, summarising and transforming raw data. Data reduction is a kind of analysis that can be applied to integrate or merge pieces of data into groups. According to research and personal experience, in qualitative research, the process of data reduction carries on throughout the study duration. Therefore, data reduction was an ongoing process. Data reduction is systematic presentation and classification of data in a manner that is convenient for easy interpretation.

3.7.2.7 Semi-structured face-to-face interviews and classroom observation checklists

The researcher analysed the data generated from the face-face interviews and the classroom observations by identifying different categories related to the research questions and the theoretical perspectives explored in Chapter 2.

The researcher established a general sense and understanding of the data, sorted and classified the data into sections, and assigning categories. The researcher examined these categories and themes to discover patterns in transcribed face-to-face interviews and classroom observation notes. Interpretive research data analysis involves developing categories and patterns interpreted through the researcher's disciplinary lenses (Ary et al. 2006:457).

Researchers are advised to go through the field notes or transcripts with a pencil while marking off segments that cohered for they pointed to the same idea, producing themes and emerging sub-themes at different stages of analysis (Miles & Huberman, 1994:57). The researcher applied the same ideas in this study. Codes not only speed up but also empower analysis, thus the researcher employed the coding system (Miles & Huberman, 1994:65). According to Corbin and Strauss (2008), coding is a system of analysing data. Codes are labels or tags for allocating segments of meaning to the probable information generated during a study (Miles & Huberman, 1994: 65). Codes can be written in the left/right-hand margin beside or even within the segments.

One manner in which codes can be developed is to create a provisional "start list" of codes before undertaking fieldwork. A start list is convenient as it demands from the researcher to link or attach the data generated directly to the conceptual interest and research questions (Miles & Huberman, 1994:65). The researcher can, however, reconsider or abandon codes should they appear inappropriate or empirically irrelevant to the text. The categories derived and were established from the research questions that underpinned this study and the conceptual framework.

The researcher formulated the codes using the categories. The researcher identified four main codes through the explored theoretical framework in Chapter 2. The codes were classified into those that illustrated the teachers' responses and experiences during face-to-face interviews and instruction. Hence, the initial letters were given to the first words in the codes and the last letters were given to the last words in the codes. This brought about four main categories, expressed in topic sentences below:

1. Retention & revision (views) (RR)

Teachers' views and how the Namibian senior secondary school mathematics teachers perceive and apply retention and revision strategies in their mathematics classrooms.

2. Teachers' challenges (TC)

Challenges experienced by mathematic teachers in the process of addressing 'the forget problem'.

3. Improving retention (IR)

How learners' retention can be improved.

4. **Studying methods (SM)**

Ways of studying retention/revision strategies of the teachers.

From the concepts and theories relevant to the research topic explored in Chapter 2 (especially from section 2.9), five subsidiary themes were also identified and drawn. These codes were sorted into categories that depicted the teachers' actions and experiences during classroom lesson facilitation. In the same way, the initial and last letters were given to the first and last letters in the codes consecutively. That resulted in five themes expressed in a form of action statements namely:

a) Probing understand

The teacher explicitly refers to mathematical conventions, definitions, symbolisms, definitions, axioms, and theorems.

b) Sense making

The teacher explicitly refers to mathematical conventions, definition, symbolisms, definitions, axioms and theorems.

c) Drive learning

The teachers use learners' views to start classroom discussions. The teachers also comment and respond to the contributions of the learners to make appropriate instructional decisions.

d) Inquisitive/exploratory discussions

Teachers encourage discussions between learners; those not interfered with by the teacher included.

e) Learner interaction

The teacher allows learners to respond and comment on the contributions of other learners.

3.7.2.8 The questionnaires

Data from the questionnaires were discussed and coded. The three questionnaires were coded by grouping the teachers' responses in each of the main sections. The teachers' responses to the structured questions were presented in a table form as illustrated in Chapter 4. The unstructured questions were coded by copying and clustering all the teachers' responses that pointed to one aspect; the aim is to identify a set of categories in which the participants' responses could be classified and sorted.

3.7.3 Areas that comprised data analysis

The qualitative oriented methodology enabled the researcher to identify and comment on relevant issues appertain to senior secondary school mathematics teachers' experiences regarding the use of retention and revision strategies in mathematics classroom teaching. All the data were discussed and classified in two sections discussed below:

- Teacher profiles per school

  The findings and analysis in the first section related to the individual teachers' personal and academic backgrounds. This formed a profile for each of the teachers. The data regarding these participants' academic backgrounds were obtained from the structured section of the face-to-face interviews (Appendix 6: Q. 1-3 & 7).

- Personal teaching experiences and beliefs

The data were gathered from the unstructured section of the semi-structured face-to-face interviews, classroom observations, and questionnaires, with specific reference to Appendixes 6-10, concerning the teachers' classroom experiences using retention and revision strategies. The classroom observation checklists (sheets) and notes afforded the researcher even more opportunities for obtaining data related to the individual teachers' classroom experiences.

3.8 LIMITATIONS AND DELINEATION

This study was limited to Namibian senior secondary school mathematics teachers at two schools from Oshikoto region in Namibia. The focus group of this study was limited to ten Grade 11 & 12 mathematics teachers (2 grade 11 teachers and 2 grade 12 teachers per school) through purposive sampling. Classroom observations were limited to four teachers from each school. The key potential limitation for this study could be convenience in terms of proximity of research site, purposive and theoretical sampling.

3.9 ASSUMPTIONS

This study was based on at least four assumptions:

- Teachers have some inherent knowledge about teaching different mathematics topics in a way that learners will retain the information longer.
- Some Namibian mathematics teachers were taught and trained, at the university level, regarding implementing different retention strategies on different school mathematics topics in their classrooms.
- Time constraint could be a major challenge making Namibian teachers' attempt in addressing the forget problem such a difficult process.
- Teachers do not have opportunities to deepen their thinking on mathematics and there could be time restrictions. All teachers can be provided with opportunities to improve learner's retention of school mathematics. Teachers could benefit from studying revision/retention strategies and improve learners' retention.
- There are some networks and research projects where retention strategies are discussed in Namibia.

3.10 TRUSTWORTHINESS

This section will depict the notion of trustworthiness as an important key to research that involves the use of qualitative data. The section will include a review of the typical and established criteria outlined in Guba and Lincoln (1985 & 1994), which were also cited by numerous researchers such as Beck & Polit (2014), Bowen (2009), Connelly (2016), Gunawan (2015), Hanley-Maxwell and Kolb (2003), Krefting (1991), Kolb (2012), LaBanca (2010), Miller (1997) and many others. Finally, the researcher will highlight the criteria applied in this study.

Trustworthiness (rigour) of the study refers to the degree of trust in data, analysis, and methods used to guarantee or establish the value of the study (Beck & Pilot, 2014, as cited in Connelly, 2016). According to LaBanca (2010), trustworthiness is about whether the findings are reliable or credible in terms of consistency and if the instruments used measured what they intended to measure. The researcher believes that trustworthiness is the accuracy of research findings and concerned with honesty or credibility, deserving of trust or ability to be relied on. Trustworthiness (truth value) of qualitative research and translucence of the conduct of a research study is critical to the usefulness or value and integrity of the findings (Cope, 2014, as cited in Connelly, 2016). Developing trustworthiness, acknowledging, and dealing with study limitations are crucial aspects in considering and demonstrating the integrity of a research project (Glesne & Peshkin, 1992, as cited in Kolb, 2012). A research study is trustworthy if and only if the readers of the project consider it to be so (Gunawan, 2015).

In any study, the researcher should develop the protocols or orders and procedures required for the study to be regarded as worthy of consideration to readers (Amakwaa, 2016, as cited in Connelly, 2016:1). Although most specialists acknowledge that trustworthiness is crucial, there have been debates in the literature as to what comprises trustworthiness (Leung, 2015, as cited in Connelly, 2016:1). Although it is hard to prove the ultimate accuracy of research, different procedures have been recognised in the literature to enhance trustworthiness (Hanley-Maxwell & Kolb, 2003, as cited in Kolb, 2012). Various procedures were incorporated into this study, which we review next.

Qualitative researchers must establish four features or aspects of trustworthiness: *credibility*, *transferability*, *dependability*, and *confirmability* (Guba & Lincoln, 1985, cited in Connelly, 2016:1). They added *authenticity* afterwards (Guba & Lincoln, 1994, cited in Connelly, 2016:1). An outline of criteria by Guba and Lincoln (1985, as cited in Connelly, 2016:1) is recognised and acknowledged by a lot of qualitative researchers. Not all procedures are applied in every study.

Credibility

Credibility is trust in the truth and thus the findings or results are the most crucial criterion (Beck & Polit, 2014, cited in Connelly, 2016:1). In qualitative research, credibility is related to internal validity (Connelly, 2016:1). Internal validity addresses the truthfulness of the data by involving the procedures of triangulation, participant engagement, and member checks (Kolb, 2012:85). The things a reader would consider would be typical standard procedures used in the qualitative approach shown and enough justification for variations (Connelly, 2016:1). Therefore, a grounded theory should be carried out (Connelly, 2016:1). Strategies used to develop credibility incorporate consistent observations and interaction with participants, member-checking, peer-briefing, and reflective field notes.

Transferability

Transferability or applicability is the extent to which the findings or results are practical or beneficial to individuals in other settings (Connelly, 2016:1). It is acknowledged to be analogous or corresponding with generalization in quantitative research. Transferability is a form of external validity (Gunawan, 2015:1). External validity focus on reliability and generalization (Kolb, 2012:85). In a qualitative study, generalization is advanced by carefully investigating the degree to which the production of the grounded theory can be applied or useful to other cases (Kolb, 2012:85). Strategies to promote the transferability of your study are providing a rich, exact description of the location, the people under study, and being transparent about analysis or interpretation and trustworthiness (Connelly, 2016:2). In other words, this means providing a vivid image that will brief and resonate with the reader (Amakwaa, 2016, as cited in Connelly, 2016:1).

Dependability

Dependability refers to the data stability over time as well as over the conditions of the study (Beck & Polit, 2014, as cited in Connelly, 2016:1). Dependability is very similar to reliability in quantitative research considering that the stability of conditions is determined by the nature of the study (Connelly, 2016:1). Strategies used to develop dependability incorporate peer-debriefing with colleagues and audit log of process logs (Connelly, 2016:1). This includes the notes of every activity taking place during the study and the preferences regarding features of the study, for example, what, when and whom to observe or interview (Connelly, 2016:1).

Confirmability

Confirmability or neutrality is the extent the results or findings are coherent and can be reproduced (Connelly, 2016:1). Confirmability is similar to objectivity in quantitative research (Beck & Polit, 2014, cited in Connelly, 2016:1). Techniques comprise the maintenance of an audit trail/log of analysis and a detailed methodological journal which are reviewed by a co-worker and may be discussed by peer-debriefing with an expert qualitative researcher (Connelly, 2016:1). Member-checks may also be conducted depending on the nature of the study (Connelly, 2016:1). All these are done to prevent biases from one individual perspective on the study.

Authenticity

Authenticity is the degree to which a researcher can completely and fairly show distinctive realities and practically express participants' experiences (Beck & Polit, 2014, cited in Connelly, 2016:1). Methods to address this criterion are selecting suitable participants for the study samples and presenting detailed, rich depiction (Hostrup, Larse, Lyngso & Poulsen, 2011, cited in Connelly, 2016:2).

Krefting (1991) as cited in LaBanca (2010) also stated that to maintain high trustworthiness in a quantitative study, four criteria to measure and ensure trustworthiness or valid interpretation of data are recognised, and they are; truth value, consistency, neutrality, and applicability. Bowen (2009) and Miller (1997) as cited in LaBanca, (2010) point out that in the quantitative approach, truth value is measured by credibility. According to the researcher, credibility is a typical example of 'quality not quantity'.

Ethical issues were taken into account from the beginning of this research study. The researcher was liable to consider unbiasedness and soundness in presenting this report. The researcher, therefore, acknowledged the idea of trustworthiness to fulfil this accountability. The researcher applied all the criteria reviewed above to assess the trustworthiness of the study. The researcher applied triangulation, participant involvement (interviews, questionnaires, and observations) and member-checking to prove credibility and thus trustworthiness. According to the researcher, credibility is a critical aspect because it requires the researcher to provide real evidence of the research study's findings, as well as to link the findings with the reality in order to demonstrate the truth of the study's findings. This was also motivated and highlighted by Frank (2010), who holds that the trustworthiness of quantitative research can be increased by maintaining high credibility and objectivity.

Triangulation entails the usage of multiple data collection methods, observation, data sources and theories to gain more complete soundness of the phenomenon under study. This, therefore, means method triangulation, triangulation of sources, analyst triangulation and theoretical triangulation. Participant engagement requires interacting with and involving the research subjects in research activities. Member-checking is the second important method that qualitative researchers employ to create credibility; it means sharing the data understanding and conclusions with the participants and is necessary for clarity, error corrections and necessary additional information. This is also necessary to obtain and secure the interpretive validity of qualitative research. Multimethod techniques such as interviews, questionnaires, and observation advance the credibility and validity of this qualitative research (McMillan & Schumacher, 2001:429). According to Stenkie (2004:184), misrepresentation and unevenhandedness that may develop from specific methods can also be taken care of.

Limited use of a single method may result in partiality and distortion of the researcher's image of the particular phenomenon (Cohen et al., 2007:141); internal validity requires that the research data can be sustained as much as quality and soundness is concerned; external validity determines research findings' applicability (Cohen et al., 2007:141). Questionnaires were piloted with non-participant teachers from a different region and member-checking was applied.

A detailed description of the people studied, location and context were provided in this study (transferability). Field notes were used and contributed to the data analysis of this study (dependability). The researcher used journals to compile a schedule about the dates, time and venues for activities that took place during the study such as piloting of questionnaires, interviews, questionnaires, observations and member-checks (confirmability). Suitable participants were also purposively selected (authenticity).

The researcher believes that the only legitimate judges of the study's results credibility are the participants or readers. Proving credibility gets the readers to trust the research and this earns the research trustworthiness. The researcher agrees to the plagiarism term and policies of the Stellenbosch University and therefore will not steal or use projects or work without citing and acknowledging the owner of the work. But the researcher will try his/her level best to also use his/her information where applicable.

3.11 ETHICAL CONSIDERATION

Gregory (2003) claims that ethics are related to principles of right and wrong and entails embracing moral issues in the context of working with humans (Le Grange, Ramrathan & Shawa, 2017). Requirements for research designs require not only information-rich participants and coherent research approaches but adherence to research ethics too (McMillan & Schumacher, 2001:420). The researcher acknowledged accountability for ethical consideration and made sure that the criteria for the research design were adhered to.

Avery important thing to put into consideration when research is conducted is to make sure that all participants are informed about how the research study will be conducted and what their involvement will be like in order for the participants to make informed decisions. For this reason, informed consent letters were obtained from the research respondents. During the informed consent, process participants validated informed voluntary consent and were assured anonymity and confidentiality.

Approval to operate in the region and to conduct the study was requested and obtained from the Oshikoto Education Directorate (Appendix 2). As this research study involved working with senior secondary school teachers in their classrooms, this required the researcher to obtain permission from the gatekeepers. The researcher acquired authority from the school principals of the two schools that participated in the study (Appendix 3). The teachers were briefed about the significance of the study and the importance of their participation, but they were also informed that their participation was voluntary and could be discontinued at any stage during the period of the study without any penalties. The researcher also obtained consent forms from both participant teachers and learners/guardians (Appendix 4).Permission to grant the researcher authority to gain access to prospective participants was obtained from Stellenbosch University. The ethical clearance application process was completed by the researcher. All ethical matters were clarified and approved by Stellenbosch University Research Ethics Committee (Appendix 1).

3.12 CONCLUSION

This chapter explored and reported details on the chosen methodology and tools used within an interpretive paradigm, particular to the research. This chapter also narrated the goal of the study and the selection of the participants to the reader. Participants might benefit directly from this intervention. All teachers were encouraged to create a platform such as mini-workshops in order for them to share their individual strategies and experiences after the observation period. The researcher also compiled and provided a handbook to all the participant teachers. This was done so that the learners who were not exposed to more explicit retention and revision strategies could also be given an opportunity to benefit from the intervention. The outcome of the study might have implications for collaboration for Namibian mathematics teachers to work together with fellow teachers or people from the directive offices to design learning materials and work on projects that can help with revision and retention. The study results may provide useful information, not only to senior secondary mathematics teachers, but also other interested individual teachers and educators to explore retention strategies as a way to aid senior secondary school learners to deal with the forget problem which is universally accepted as one of the major contributing factors to poor achievement in Mathematics tests and examinations. The chapter concluded by discussing the trustworthiness and the ethical considerations of the study. The research findings and analysis are dealt with in the following chapter.

CHAPTER 4

FINDINGS AND DISCUSSIONS

4.1 INTRODUCTION

Chapter 3 delineated how the investigations for the empirical side of this study were conducted and the theoretical framework. This chapter will present and analyse the empirical results of the study chronologically as they emerged during the three phases stated in Chapter 3. The results were developed from the face-to-face interviews of the ten teachers, classroom observations of 8 of the teachers who were chosen as suitable cases for the study as well as the questionnaires completed by the 10 ten teachers.

Analysis and discussions are presented for teachers, per teacher, per school for the interviews and classroom observations. The questionnaires are analysed, discussed, and presented collectively for both schools. The emerging themes were identified and established on the study's unit of analysis: teacher's perceptions and mathematics teaching experiences using revision and retention strategies. Triangulation of data obtained from the various data collection methods was to figure out the extent to which the sets of data complemented one another as well as to check for semblances of emerging themes or commonalities and variations. Data collection was from two different schools, four cases for each school. Alphabetical letters indicated the schools and pseudonyms are used to indicate participant teachers to secure their identity. The qualitative data enabled the researcher to identify comments on critical issues related to how the Namibian senior secondary school mathematics teachers perceive and experience the facilitation of mathematics through retention and revision strategies. The researcher examined and compared all the data collected in the three data collection phases indicated below.

4.2 PARTICIPANT SCHOOLS' BACKGROUND

The analysis is related to a brief background of the participant schools. Both schools are urban schools and start from Grade 8 up to Grade 12. In an attempt to give a more realistic view in answering the research question, the researcher purposively chose urban schools as schools in urban areas are most likely to be better equipped in terms of teaching and learning resources. The attitude of the two schools towards the teaching of mathematics and mathematics as a subject is satisfactory based on the teacher classroom allocations, arrangements, and the researcher's observations while visiting the schools.

At all the schools, teachers have their classrooms, to which learners move before each period begins, instead of teachers following learners to other classrooms. This individual classroom allocation was convenient to avoid setting up the classes every time the teachers are moving through the day. Furthermore, the idea is found suitable for promoting cooperative learning and learner-centred education.

Both schools have some similar and different arrangements with regard to their teachers. At school A, the mathematics teachers are expected to move with their grades 11 learners to grade 12 the following year. This was done so that the individual teacher can complete the whole two-year course (Grade 11 and 12) with his/her learners. Also, it was considered helpful, and it is believed that the learners will get used to one teacher's teaching methods. Unlike school A, at School B, teachers switch. It is believed that at schools where teachers move from classroom to classroom, learners have the advantage of being exposed to a variety of teaching methods. The teacher-to-learner ratio is not well managed at both schools and varied for every individual teacher as it is beyond the affirmed limit of at least 1:35. School A has six teachers who teach grades 11-12 mathematics and school B has four teachers. The researcher has observed that the cooperation among the mathematics teachers at each school is good and they can work as a team. All the teachers are also always accessible to support one another, but it is unlikely for one to go to another or meet as a group to ask questions, share comments or even teaching strategies on how to approach different topics. As outlined in Chapter 3, these schools were part of a purposive sample (See 3.7.1.1).

School A	School B
Urban school	Urban school
Grade 8-12	Grade 8-12
Good attitude towards the teaching of mathematics and mathematics as a subject	Good attitude towards the teaching of mathematics and mathematics as a subject
Teachers have their own classrooms	Teachers have their own classrooms
Teachers move with their grade 11 learners to grade 12	Teachers swap classes every year
Poor management of teacher-to-learner ratio ranging from 1: 45 and up	Poor learner-to-teacher ratio management ranging from 1: 45 and up
6 grades 11-12 mathematics teachers	4 grades 11 -12 teachers
3 teachers for grade 11 mathematics	2 grade 11 mathematics teachers
5 grade 11 mathematics classes	3 grade 11 mathematics classes
3 teachers for grade 12 mathematics	3 grade 12 mathematics teachers
4 grade 12 mathematics classes	3 grade 12 mathematics classes
Teachers do not meet to share teaching strategies	No meetings to discuss or to share teaching approaches

4.3 TEACHER PROFILES PER SCHOOL

The main intention of the researcher in reporting on individual teachers' profiles was to give an insight into why their responses and practices may be the way they are. The personal academic backgrounds of the four cases (teachers) selected for classroom observations per school may also provide insight into the findings and analysis as well as the emerging themes to be presented with regards to the study.

The data regarding these participants' academic backgrounds were obtained from the structured section of the face-to-face interviews (Q. 1-3 & 7). The face-to-face interviews constituted a total number of six questions. Therefore, half of the interview was unstructured. Based on the interview questions, the researcher wanted to find out whether the years of experience in the profession or mathematics subject in the particular grades and the level of qualification matters with regard to how Namibian teachers perceive and use retention and revision strategies.

School A

Grade 12

Teacher Edson (Pseudonym)

Teacher Edson started teaching in the year 1999 but started teaching mathematics for grades 11 and 12 in 2004. He has, therefore, been in the teaching industry for 20 years and has 15 years of mathematics grade 11 and 12 teaching experience. Teacher Edson has a Bachelor of Science degree and a Math 1 High Education Diploma in mathematics (ordinary and high level) from a national university. He teaches grade 12 high level. He stated that there are more responsibilities for him as the school's headmaster and that it would be inconvenient and would interfere with completing his schemes of work on time so that he was unable to be part of the classroom observations. However, he stated he was willing to complete the questionnaires.

Teacher Zimkitha (Pseudonym)

Teacher Zimkitha has eight years of teaching experience and has taught grades 11 and 12 mathematics for eight years. Her highest qualification is a Diploma in Senior Secondary School Mathematics Education from an international university.

Teacher Khosi (Pseudonym)

Teacher Khosi is five years in the teaching profession and has taught grades 11 and 12 mathematics for five years. Her highest qualification is a Basic Education Teaching Diploma (BETD) from a nearby college and an Advanced Certificate (ACE) in Senior Secondary School Mathematics Education from an international university.

Grade 11

Teacher Bimboo (Pseudonym)

Teacher Bimboo is six years in the teaching industry and has taught grades 11 and 12 mathematics for six years. Her highest qualification is a Bachelor of Education Honours Degree in Senior Secondary School Mathematics from a national University. Teacher Bimboo was pleased to be part of the study and to be observed.

Teacher Lucia (Pseudonym)

Teacher Lucia is currently 13 years in the teaching profession and has taught grades 11 and 12 mathematics for 12 years. Like teacher Bimboo, she also holds a Bachelor of Education Honours Degree in Senior Secondary School Mathematics from a national university as her highest qualification. Teacher Lucia was excited to be part of the study and was willing to be observed.

Teacher Vida (Pseudonym)

Teacher Vida has been in the teaching profession for seven years and has taught secondary school mathematics for six years. She completed a Bachelor of Education Honours Degree in Senior Secondary School Mathematics from a local university. She was also willing to be part of the classroom observations, but due to purposive sampling, and considering years of teaching experience (See 3.7.1.1), there could only be two grade 11 teachers from each school.

School B

Grade 12

Teacher Angelo (Pseudonym)

Teacher Angelo is 15 years in the teaching profession and has taught grades 11 and 12 mathematics for ten years. His highest qualification is a Bachelor of Education Honours Degree in Senior Secondary School Mathematics from a national university. Teacher Angelo was willing to be part of the study and observations. "*I'm not the best mathematics teacher but I will never deny you to visit my class [smiles].*"

Teacher Idaresit (Pseudonym)

Teacher Idaresit has six years of teaching experience and has taught grades 11 and 12 mathematics for four years. Her highest qualification is a Bachelor of Education Honours Degree in Senior Secondary School Mathematics from a national university. Teacher Idaresit stated that the researcher was welcome to visit her class for observation as long as she notified her in advance.

Grade 11

Teacher Freddy (Pseudonym)

Teacher Freddy has one year of teaching experience and has taught grades 11 Mathematics for one year. He holds a Bachelor of Science Degree from a national university. Teacher Freddy stated that the researcher was welcome to visit his class.

Teacher Awino (Pseudonym)

Teacher Awino has seven years of teaching experience and has taught grades 11 and 12 mathematics for seven years. His highest qualification is a Basic Education Teaching Diploma (BETD) from a local college and an Advanced Certificate (ACE) in Senior Secondary School Mathematics Education from an international institution. Teacher Awino seemed to be excited to be part of the study. He asserted that he likes class visits and finds them a positive way of criticism and learning from one another.

All four teachers from school B were willing to be part of the study and classroom observations.

From the teachers' profiles narrated above, the names of the selected teachers for classroom observations at school A were Zimkitha and Khosi for grade 12, Bimboo, and Lucia for grade 11 (Pseudonyms). The names of the teachers who were observed from school B were Angelo and Idaresit for grade 12 as well as Awino and Freddy for grade 11 (Pseudonyms). The teacher with the maximum number of years of teaching experience from the eight selected teachers is teacher Angelo with 15 years. The teacher with the maximum number of Grades 11-12 mathematics teaching experience has 12 years of experience (Teacher Lucia). The teacher with the minimum number of years in the teaching industry is teacher Freddy with one year of teaching experience. Teacher Freddy is a qualified teacher but is not qualified for teaching mathematics. Seven of the eight selected teachers represented qualified senior secondary school mathematics teachers.

4.4 PERSONAL TEACHING EXPERIENCES AND BELIEFS

This section will chronologically present data gathered through the interviews, classroom observations, as well as the questionnaires. It will give and discuss the interview data from the ten teachers from the two schools, including the eight scrutinized teachers. The eight cases came about as part of the purposive sampling to further establish a grounded theory (see 3.7.1.1 and 3.7.2.4). The researcher also came up with the eight teachers to have an equal number of teachers for observations from each school.

As reported in the methods chapter, through content analysis, constant comparative and theoretical sampling methods, the researcher identified themes and emerging sub-themes produced to develop a grounded theory (see 3.7.2). Through the explored framework in Chapter 2, the researcher identified four aspects. These are aspects that may lead to answering the main research question as well as the sub-questions. The four themes were also based on the literature as that may add to an improved way of teaching that may benefit learners' retention of school mathematics. The presentation of the research findings focused on the four aspects below as the four identified themes.

1. Teachers' views and how the Namibian senior secondary school mathematics teachers apply retention and revision strategies in their mathematics classrooms.

2. Challenges experienced by mathematic teachers in the process of addressing 'the forget problem'.

3. How learners' retention can be improved.

4. Ways of studying retention/revision strategies of the teachers.

From the face-to-face interviews and the questionnaires, the researcher, therefore, identified the questions that pointed to the same aspect/theme. For easy interpretation, table 4.1 below outlines the ideas that addressed each component. The codes depicted the teachers' views on the aspects given.

Table 4.1 Identified themes and codes

	Interview	***Questionnaires***		
	Interviews **(Appendix 6)**	Questionnaire1 **(Appendix 8)**	Questionnaire 2 **(Appendix 9)**	Questionnaire 3 **(Appendix 10)**
Aspects/Themes (Codes)	Questions:	Questions:	Questions:	Questions:
1. Retention & revision strategies (views) (RR)	4-6	1-9	Part A & Qs 1-6	1
2.Teachers' challenges (TC)		10		
3. Improving retention (IR)		11		
4. Studying methods of the teacher (SM)			7	

4.4.1 Face-to-face interviews with the 10 teachers (Appendix 6)

The interview was the first phase of data collection conducted by the researcher. Besides the structured questions that aimed at constructing the individual profiles of the teachers, interviews consisted of three unstructured questions regarding the teachers' teaching practices and experiences of retention and revision strategies, from questions 4-6 of the semi-structured interview. The section below comprises the discussion and analysis of the teachers' responses to these general unstructured interview questions where the researcher gets their perspectives, in pursuit of answering the main research question:

How do Namibian senior secondary school mathematics teachers perceive and experience the facilitation of mathematics through retention and revision strategies? The responses were from the ten teachers, eight selected cases inclusive. The questions were as follow:

4. As a senior secondary school mathematics teacher, what do you do as a way of helping your learners deal with forgetting? Give examples of the strategies you use.

5. What do you understand about retention (memorization) and revision strategies?

6. Would you elaborate more on your answer to question 5?

First and foremost, the researcher learned and took note during the interviews as the first phase and interaction with the teachers that none of the 10 participant cases knew about the notions of retention and revision strategies. Based on their answers to question 4, the data indicated that the teachers are at some points using some of the retention and revision strategies in their everyday classroom situations even though their answers to question 5-6 prove that the teachers do not refer to the terms retention or revision strategies. Thus, it is evident that the teachers might not know the special terms identified with the strategies they use, and might not have fully recognised the importance of incorporating these strategies in every lesson as possible but they know and use some of these strategies to a certain point. The data collected from the teachers during the interviews showed that most of the teachers have intuitive knowledge about revision strategies even though they could not give explicit definitions and explanations (see 2.3, para. 4).

As stated earlier, teachers did not know the theory behind the notions of revision and retention strategies. The researcher observed during the interviews that the teachers who managed to figure out the definition for revision strategies did so only because the notion of 'revision' is self-explanatory and kind of has an obvious meaning. The researcher can claim the statement above because the teachers could not point out the particular types of revision strategies. The researcher has also observed and learned that it was only after she told the participants that 'retention strategies' are also referred to as memorization strategies that some teachers started relating to the idea. Only after that, the researcher was able to obtain some responses from the respondents. The researcher believes that the words 'revision' and 'memorization' are helpful prompts to the meaning of memorization and retention strategies. The teachers wouldn't know theory because they don't work with theory. Teachers have not thought through or done their work of teaching in ways that the researcher describes. The teachers do have their peculiar revision and retention strategies but they've not examined them in a concerted way. The interactions with them have made them aware and more conscious of revision and retention strategies. In the section below are the teachers' responses to the interview questions shown above. The analysis of every teacher's response can be found thereafter.

4.4.1.1 Retention and revision strategies (Appendix 6)

School A

Grade 11

Teacher Vida (Pseudonym)

Q. 4.

"I emphasise the competencies especially the challenging ones, emphasizing challenging learning content. I stress visualizations, for example, writing formulas in bold on the chalkboard e.g. the quadratic formula or Pythagoras theorem".

What teacher Vida said above seemed to indicate repetition (as seen in the teacher's response: 'emphasizing') and some forms of visualizations. Her comments therefore, acknowledge memorization which is also known as retention strategies. The process of memorization involves repeating or emphasizing skills until they can be recalled by heart.

It is a way of attaching information to memory. Ideas can be memorized in various ways and applying several strategies like visualization, mnemonics, and rote learning, to mention a few(Hoque, 2019:2). From the interview, the teacher's ideas of repetition seemed to relate to the memorization strategy of drill-and-practice. Drill-and-practice is a process where the teacher uses repetitive exercises, problems, or non-problem-based activities or tasks meant to enhance procedures already dealt with (Van De Wale et al., 2010:69). According to Van De Wale et al., (2010:69), drill entails repetitive non-problem-based exercises designed to advance work already learned whereas practice indicates various problem-based exercises spread over sessions. Literature points out practice as more productive in opposition to drill.

Drill is limited to focusing on a single procedure excluding flexible alternatives and false image of understanding (Van De Wale et al., 2010:69). Drill also gives a procedural or rule-oriented view of what mathematics is about (Van De Wale et al., 2010:69). Practice enhances learners' opportunities to develop explicit and useful cognitive ideas, connections and strategies (Van De Wale et al., 2010:70). However, drill has a place in mathematics and can provide learners with a review of procedures or ideas so they are retained (not forgotten) and an enhanced ability with procedures, though only procedures already learned (Van De Wale et al., 2010:69).

Both drill and practice can be given as homework, for example; however, lengthy or frequent drill is not productive (Van De Wale et al., 2010:70-71). 'Visualizations' from the teachers' response may also relate to some specific kinds of mnemonics.

According to Bah et al. (2019: 94), the types of mnemonics associated with key letters, forming words from first letters, abbreviations or phrases such as those used to memorise formulas, as expressed by the teachers are referred to as acronyms or acrostic-like acronyms (See section 2.3.1.1). Overall, the teachers highlighted retention strategies of visualizations, visual and verbal memory hints or mnemonics, and drill-and-practice.

Q. 5 & 6

"Like I said before, revision is, for example, quizzes that I give to learners after teaching the learners a particular topic. I don't know what memorization strategies are, but I think they are ways of helping learners to remember things that were done. For an example, with linear inequalities. When it comes to the relationship signs of less than and greater than (<>), I use a strategy of using their arms. A strategy of telling them to use their arms works based on where you are facing when you are writing on the chalkboard or a paper. The sign that looks like a bent right hand is called "greater than" keeping in mind that in most cases the right hand is stronger, and vice versa". "I think revision strategies are ways that you use to revise with the learners after you have already taught them like quizzes. I don't know what retention strategies are."

The information above seems to show that the teacher has some ideas on what retention and revision strategies are about. The teacher expressed ideas of some forms of verbal and visual prompts as a way to assist her learners with the problem of forgetting. The visual and verbal prompts expressed by the teacher about the relationship signs seemed to be consonant with the *Loci Techniques* by Bah et al. (2019: 94). These include a mnemonic technique whereby one relates or associates a place or an object recognized or identified for something to be recalled by forming and organizing mental images. These loci technique visualizations make remembering easier (Bah et al., 2019: 93). The teacher's idea about quizzes showed that she had an idea that revision strategies had to do with doing work that has already been dealt with (Julie, 2011:4). In general, from the interview, the teacher addressed the retention strategies of visualizations, mnemonics and drill-and-practice.

Grade 12

Teacher Edson

Q. 4.

"I advise my learners that mathematics is a universal language. I repeat and write down information on the chalkboard. I emphasise 'Theory into practice'. I also try to be practical at every possible time. I use concrete objects. I give my learners immediate feedback".

Teacher Edson has his ways of helping his learners with the 'forget problem'. From the limited time of the interview, his ideas of *'repeat and write on the chalkboard'* and *'Theory into practice'* appeared to point to the views about rote learning and drill-and- practice explained earlier. Rote learning is a memorization strategy based on repetition (Mayer, 2002:227). However, 'theory into practice' can be linked to some other forms of retention and revision strategies. Drill entails doing non-problem-based repetitive activities and exercises to improve procedures already done; practice encompasses various problem-based tasks spread over classroom periods, each addressing the same ideas (Van De Wale et al., 2010:69).

Q. 5 & 6

"I don't have an idea about retention strategies. I don't know how to define revision strategies. For example, revision is homework, projects, practical investigations, and exercises. I always revise one topic at a time".

The examples of revision strategies by teacher Edson conform to overlearning and massed practice as he says he revises one topic at a time, thus implying that revisions or practice sets are on not more than one idea (Rohrer & Taylor, 2006). As expressed from all the above, the retention strategy specified by teacher Edson is drill-and-practice (repetitive problem and non-problem based activities), and the revision strategies are massed practice (many practice problems focused on one topic within one practice set) and overlearning (questions on one topic spread over more practice sets) (Rohrer & Taylor, 2006).

The Eight selected teachers (see Appendix 6)

This part presents the views of the four scrutinised teachers per school. In this section, the researcher analyses and discusses the ideas of the eight selected teachers on the use of retention and revision strategies.

School A

Grade 11

Teacher Bimboo (Pseudonym)

Q. 4.

"I ask learners to write down formulas in a list in their books and ask them to memorize them. After teaching them something during the lesson, I make all the learners stand and sit after they have correctly answered questions I ask them at random. When we discuss corrections to homework, I ask the learners to solve the sums on the chalkboard. After each chapter, I revise the key ideas about the chapter with the learners and allow them to ask questions before the test."

Teacher Bimboo indicates a retention strategy such as allowing learners to memorise formulas as her ways of helping learners with the 'forget problem'. As a result, she is providing learners with an opportunity to use the verbal or visual prompts to remember the letters, numbers, sounds, and images involved in the formulas. The revision strategies emerging from the teacher's comments above point to massed practice and overlearning for the teacher gave the impression that she assesses homework, tests, and revises one chapter at a time. Massed practice requires that practice questions are from one topic and are collected or massed into one practice session (Rohrer & Taylor, 2006). Overlearning implies that practice problems from the same topic are spread across two or more practice sessions (Rohrer & Taylor, 2006).

Q. 5 & 6

"Revision means that you teach a content first, and teach it again. I think memorization strategies are learning contents that help learners to remember something".

"Revision, for example, is the tests that I give after every chapter and lots of homework. I revise a chapter at a time. I also ask learners to give problems that should be solved by all the learners".

From the comments to question 5 and 6, teacher Bimboo's comments, just like in the first question, once more conform to revision strategies of overlearning and massed practice. Her classroom practice of discussing and revising one chapter at a time assures massed and overlearning. Therefore, teacher Bimboo in all the comments above highlights retention strategy mnemonics, and revision strategies, overlearning and massed practice.

Teacher Lucia (Pseudonym)

Q. 4.

"In most cases, I repeat previously learned work. I like to link new content to previously learned content when the new learning content requires some of the content from previously taught material for it to be understood because two learning contents are linked (have connections). I like to revise with past examination papers".

Teacher Lucia showed that she is doing something to help her learners with the 'forget problem' for example repeating of previous work. The teacher's comments are in line with a memorization strategy of drill-and-practice, *repetitive* problems, and non-problem-based exercises for reinforcing taught material (Van De Wale et al., 2010:69). Non-problem-based exercises imply that learners are not required to solve open-ended problems. The teacher's responses have also demonstrated that the teacher uses a revision strategy of exam-driven teaching. 'EDT' implies teaching previous examinations and content believed likely to come up in the upcoming examinations (Julie, 2013b:3). Also, research has shown that creating opportunities for learners to link new ideas to their existing knowledge forms part of the support system for retention. Research has shown that linking information to existing knowledge enhances the likelihood of understanding and remembering.

Q. 5 & 6

"I think memorizations are strategies that you use during the presentation of the lesson, and you tell your learners, for you to remember this, you have to use this strategy. Revision, you revisit what you have already done with the learners."

"An example of a memorization strategy that I use is, for example, a Speed, Distance, and Time triangle to help learners memorize the formulas to calculate time or distance or speed. Depending on what we are revising, I normally put sums on the chalkboard and ask learners to voluntarily solve it on the chalkboard and ask all the learners to write the correct answers in their exercise books.
Sometimes I hand out copies of past examination question papers to all the learners to work on their own and allow them to ask questions where they struggle. Then we discuss the question as a group during lessons. Sometimes I give them these question papers as a test, mark them, return them to the learners, and then do corrections together on the chalkboard. I also give a few sums on the chalkboard where learners answer individually in their exercise books while I go around the class and mark".

By helping the learners to memorise formulas, the teacher's comments expressed that she uses mnemonics strategies, strategies for providing visual or verbal stimulation, or prompts for learners who may experience challenges in keeping and remembering information (DeLashmutt, 2007). The literature reviewed in Chapter 2 showed and validated that models/image mnemonics, actual models, pictures, graphs, similar devices and images such as the chart used by teacher Lucia for distance/speed/time, are some of the retention strategies that teachers can use in a form of visualizations or mnemonics. Teacher Lucia's comments and ideas of allowing her learners to discuss the answers on the chalkboard as a class also support the ideas of Julie (2011), who suggests that teachers can have their class discuss the solutions on the chalkboard instead of marking the learners' work to contribute more to learning. Working out past examinations' practice problems with the learners ensures exam-driven teaching (Van De Wale et al., 2010). Examinations constitute valuable knowledge of the intended mathematics curriculum (Bishop, Hart, Lerman & Nunes, 1993:11, cited in Julie, 2013b:4 and Okitowamba, 2018:4). In conclusion, teacher Lucia indicated mnemonics, drill-and-practice (retention strategy), and exam-driven teaching (revision strategy).

Grade 12

Teacher Zimkitha (Pseudonym)

Q. 4. (See Appendix 6)

"During every next lesson, we revise the previous lesson. I like to give the learners surprise tests, and then they know they always have to go back to the work they have learned. I also like using past question papers to revise with the learners".

Teacher Zimkitha expressed some revision strategies of helping her learners with the problem of forgetting, for example surprise tests and past question papers. The manner in which she gives the surprise tests (e.g. tests covering problems from different topics or the same topic) can determine the type of revision strategy the teacher uses.

The use of past examination question papers is consonant with the revision strategy of exam-driven teaching. Revising past question papers shows that the teacher is aware of the pressure of examinations as an integral part of the schooling system which tends to determine the implemented curriculum or what the teachers teach (Bishop, Hart, Lerman & Nunes, 1993:11, cited in Julie, 2013b:4 and Okitowamba, 2018:4). Teaching will always be governed by what is examined because the schooling system entails intended, implemented and examined curricula (Burkhardt & Pollak, 2006; Van den Heuvel-Panhuizen & Becker, 2003 cited in Julie, 2013b:4). The intended and the interpreted curriculum only determine the teaching scope but the implemented curriculum should comply with the examined curriculum (Julie, 2013b; Okitowamba, 2018:4).

Q. 5 & 6

"I am not aware or sure about revision and retention strategies; maybe I can give examples."

"Revision, surprise tests, exercises, I'm a type of 'practice makes perfect' so I let my learners do lots of practice. Memorization: I let learners memorise formulas".

From the teachers' comments and expressions above, allowing learners to memorize formulas highlights some sorts of memorization or retention strategies from the teacher. Surprise tests and exercises indicate a type of revision. In conclusion, the revision strategy, based on the limited interaction I had with her and expressed by teacher Zimkitha is a version exam-driven teaching. Surely, the latter implies preparation of some sort, that is, revision. The schooling system is structured by these three versions of the curriculum.

Teacher Khosi (Pseudonym)

Q. 4.

"I use visual display most of the time for the contents that learners can memorize. I advise the learners to practice on their own using a variety of past examination question papers and textbooks".

From the comments, teacher Khosi's retention strategy is visual display. Visualizations stated by the teacher forms part of memorization strategies (Hoque, 2019:2). Practising through past question papers is consistent with exam-driven teaching described by Julie (2013b:3).

Q. 5 & 6

"Revision is doing something that I have already done with my learners. Memorization is a way of teaching that can help the learners to memorise."

"Revision, for example, I come up with questions (compiling a task) where learners answer individually and hand in for me to mark, and then we do correction together on the chalkboard. Sitting in groups, work out questions in groups, learner-centred, and peer-teaching. Memorization, for example, diagrams. Mostly I use concrete objects."

The diagrams stated by the teacher are, generally, used as various ways of visualizations, a memorization/retention strategy (Hoque, and 2019:2). Doing the corrections together with the learners on the chalkboard contributes to meaningful learning, depending on how she does it. According to Julie (2011:6), writing the learners' answers on the chalkboard and discussing with them whether they are correct or incorrect adds much more to learning than marking their work.

Overall, the teacher's interview comments pointed to exam-driven teaching (revision strategy) and visualization (retention strategy) explained earlier.

School B

Grade 11

Teacher Awino (Pseudonym)

Q. 4. (See Appendix 6)

"I encourage my learners to work as a team with other learners, regardless of grade levels. I encourage learners to use past question papers, keep old notes, and create their own libraries. I give learners past question papers to work on their own and give individual comments and assistance, then discuss problematic questions with the whole class."

Teacher Awino stated that he discusses past question papers with the learners, which guarantees exam-driven teaching, a revision strategy. Exam-driven teaching, which also means teaching to test, is a form of revision. Teachers who teach to test cover a balanced and rich content (Okitowamba, 2018:4). Also, encouraging his learners to work on their own and in groups is a suggestible and recommended classroom procedure that promotes learner-centred education, cooperative learning and learner interaction. The idea of learners working without the interference of the teacher and working in groups not only focuses the instruction process to the learners (learner-centred education) but also created opportunities for learners of mixed abilities to work together in one group (cooperative learning) and encouraged learner interaction which contributed to meaningful learning and retention.

Q. 5 & 6

"Are you asking that I me to define them? I am not sure how to define them but I can give examples."

"Revision: I do for example classwork and tests. I normally revise a topic at a time, sub-topic by sub-topic, and for tests I combine all sub-topics to make a topic test. Memorization: it depends on the topic. I use different memorization strategies for example when I need learners to memorise formulas. For example, I attach popular words to the formulas. For example, when I want learners to memorise the formula for calculating the area of a triangle I tell them that $Area = \frac{1}{2} \times ben \times hauwanga$ *which refers to* $A = \frac{1}{2}bh$.

Ben Hauwanga is the name of one of the popular Namibian businessmen. However, I still teach the learners that 'b' stands for 'breadth' and 'h' stands for height".

Teacher Awino could relate to revision strategies for examples classwork and tests. The examples provided by teacher Awino point to overlearning and massed practice for his comments indicate that his ways of revision involve not more than one topic at a time. Massed practice requires that similar practice problems are collected in one practice session and overlearning indicates a distribution of similar problems across various topics (Rohrer & Taylor, 2006). 'Sub-topic by sub-topic' relates more to overlearning. The strategy the teacher uses to help his learners memorise the formula for calculating the area of a triangle seems to be consonant with the *connect technique* by Bah et al. (2019). According to Bah et al. (2019: 94), the connect system is mnemonic that involves relating or associating a word with another, creating a realistic or logical and illogical connection that can prompt one's memory. As a result, teacher Awino seems to indicate mnemonics (memorization strategy), overlearning, massed practice and exam-driven teaching (revision strategies).

Teacher Freddy (Pseudonym)

Q. 4.

"I like to give my learners more practical exercises to practice on their own, during the lessons and at home, and then we discuss the answers together before the following lesson."

Teacher Freddy indicated practice as a way to help his learners deal with forgetting. Practice entails spreading various problem-based experiences or tasks over a number of lessons or periods, each directed to the same key ideas (Van De Wale et al., 2010:69). His idea of discussing answers with the learners in the class adds more to meaningful learning than marking the work of the learners (Julie, 2011:6).

Q. 5 & 6

"Are you asking for the definition? [Laughs...] No, I don't know the definitions."

"When it comes to memorization strategies, I can't think of one at the moment. Revision strategies mostly I use previous tests and examination question papers, giving learners to work them out on their own first and mark them, and then discus correction in the class doing the whole question paper together with the learners."

Teacher Freddy indicated previous tests and examination papers which are used for retention and revision purposes when it comes to test taking. His ideas of discussing answers with the learners add more to meaningful learning than marking (Julie, 2011:6). Thus, a revision strategy evident from teacher Freddy's interview comments is exam-driven teaching which is also known as teaching to test. According to Julie (2013), cited in Okitowamba (2018:4), examination-driven teaching can contribute to meaningful learning (Julie, 2013, cited in Okitowamba, 2018:4). The schooling system is structured by the intended, the implemented and examined curriculum, so the examined curriculum guides the implemented curriculum or what is taught (Bishop, Hart, Lerman & Nunes, 1993:11, cited in Julie, 2013b:4 and Okitowamba, 2018:4). Examinations constitute legitimate and relevant mathematics curriculum knowledge (Bishop, Hart, Lerman & Nunes, 1993:11, cited in Julie, 2013b:4 and Okitowamba, 2018:4).

Grade 12

Teacher Angelo (Pseudonym)

Q. 4.

"Well, these are the things that I do:
"I tell them how the mind works. That they have to transfer what they learn from the working memory to the permanent memory. To achieve this, I repeat the content with them, associating the content with what they already know. When you walk on a path many times, you get more familiar. It is the same as repetition. When I teach, I like to organize content in groups to make learning easier. When you don't have a linking system, you can't easily recall. Like with mnemonics, *they function as a filing system. Mnemonics link you to everything you need to remember. Another thing is attaching importance to what you learn. The mind remembers better what regarded as important. That is why when we teach learners, it's good telling them where the content applies in real life. I also advise learners to rest (sleep enough), avoid learning too much at the same time, timing, and breaks are needed. During the awards ceremony, I do presentations on strategies/methods of studying".*

Teacher Angelo expressed various ways of how he assists his learners to deal with the 'forget problem'. Teacher Angelo's expressions of repetition appeared to support 'drill-and-practice', a memorization strategy. Drill implies that the teacher uses repetitive non-problem-based (close-ended or structured) activities while practice provides problem-based activities aimed at enhancing procedures or content already dealt with during an instructional session (Van De Wale et al., 2010:69). The teacher referred to associating new ideas with the existing ideas of the learners. His views about organizing and grouping ideas so that they can be easily assimilated by the mind seemed to suggest Ausubel's idea of 'advance organizers'.

In Ausubel's view, learners are required to link new ideas to their pre-knowledge, to learn in a meaningful manner (Novak, 2002: 549). Advance organizers are a small amount of verbal, visual, graphic, or written information that is given to learners preceding new learning material during a teaching session (Lefrancois, 1997, in(Guthua & Nyabwa, 2008).Teacher Angelo pointed out a type of retention strategy (mnemonics). Mnemonics are memory driving techniques to recall ideas by associating them with easy forms of information and data (Bah et al., 2019: 94).

Q. 5 & 6

"Retention and revision strategies... I can maybe give examples."

"Memorization; I group and organize the content in a way that it can easily be taken up by the mind. Revision; for example, doing past question papers with the learners and discussing corrections with them in the class.

Sometimes, I like marking out or identifying topics that were previously poorly performed by the learners, then pick different questions from different question papers and compile class activities for learners to work out independently."

Here, teacher Angelo highlights a revision strategy of exam-driven teaching by doing past examination question papers with the learners. Identifying topics of concern and compiling assessment tasks out of that assures distributed practice. Overall, teacher Angelo highlighted mnemonics, advance organizers, drill-and-practice (memorization strategies), as well as exam-driven teaching and distributed practice (revision strategy), based on the interactions he had with the researcher in the interview.

Teacher Idaresit (Pseudonym)

Q. 4.

"The things I use mostly, are, for example, repeating a learning content many times and testing the learners a lot, formally and informally. Working out past question papers with the learners and using concrete objects, for example, nets, because learners learn better when they are seeing".

Teacher Idaresit indicated that she has some ways of addressing 'the forget question'. Working on past examination question papers guarantees exam-driven teaching (revision strategy), and the use of concrete objects assures visualizations (memorization strategy).

Q. 5 & 6

"I don't know the definitions".
"Memorization is, for example, how learners memorise CAST and SOH CAH TOA. Mostly for revision for grade 12 I do revision after the content for the term using old question papers. I give question papers to the learners to go and work on their own and then we discuss corrections in the class as a group. I also give them past question papers as a pre-examination (mastery test) when the whole term content is covered as preparation for the examination. During classwork, homework, and tests, I test the learners per topic."

Teacher Idaresit mentioned CAST and SOH CAH TOA. These two are mnemonics. Her comments suggest acronyms and acrostic-like acronyms (see 2.3.1.1). Acronyms mnemonics imply forming words from the letters at the beginning of a series of words such as CAST (Bih et al., 2019: 94). Acrostic-like acronyms too entail using main letters to make the abstract idea more specific and easier to recall (Bih et al., 2019: 94). However, acrostic-like acronyms do not necessarily have to use the first letter all the time or abbreviations; it can be a word or phrase (Bih et al., 2019: 94) such as SOH CAH TOA. Her idea of testing learners by discussing old question papers with the learners is a revision strategy and correlates to exam-driven teaching (Julie, 2013). In conclusion, from the interview interactions the researcher had with teacher, Idaresit highlighted visualization (memorization strategy), and exam-driven teaching (revision strategies).

Table 4.2 summarises the discussions above concerning the main research question and thus presents the various memorization and revision strategies that were highlighted or referred to by the different teachers during the interviews per school per teacher. The strategies were as indicated below.

Table 4.2 Summary of the teachers' interview comments on retention and revision strategies

	TEACHERS									
	SCHOOL A						**SCHOOL B**			
	Vida	**Edson**	**Bimboo**	**Lucia**	**Zimkitha**	**Khosi**	**Awino**	**Freddy**	**Angelo**	**Ida**
RETENTION STRATEGIES										
RETENTION (MEMORIZATION) STRATEGIES										
Visualizations						✓				✓
Mnemonics	✓	✓	✓				✓		✓	

Drill-&-Practice	✓			✓					✓	
Advance organizers									✓	
Rote learning										
REVISION STRATEGIES										
Massed practice		✓	✓				✓			
Overlearning		✓	✓				✓			
Exam-Driven-Teaching				✓	✓	✓	✓	✓	✓	✓
Distributed practice				✓					✓	
Productive practice: Spiral revision Deepening Mathematical Thinking										

Teachers have their peculiar retention and revision strategies. After the researcher prompted that retention strategies are also known as memorization strategies, some could also eventually relate to the notions of retention and revision strategies by connecting meanings to the concepts of ‘revision’ and ‘memorization’. From the interviews above, the researcher noticed that the teachers have limited theory understanding or perceptions but use some of the retention and revision strategies in their classrooms. The majority of the teachers mostly highlighted visualizations, mnemonics, and drill-and-practice with advance organizers rarely mentioned (memorization strategies). Mostly the teachers pointed to overlearning, massed practice, exam-driven practice, or distributed practice. None of the teachers referred to productive practice, spiral revision, or deepening mathematical thinking (revision strategies).

From the responses above, the researcher thinks that the teachers could learn and do more about retention and revision strategies. The researcher believes that if the teachers can have more opportunities to explore retention strategies, they would apply them more often and effectively. They might also recognize the significance of using them more often. The researcher also believes that there is even a lot more that the teachers are capable of knowing and doing, and they may become more passionate about teaching through retention strategies should they be provided with more opportunities through collaboration work. The researcher’s interactions with them have made them more aware or conscious of and in a way enthusiastic about ‘revision and retention’ strategies. The other goal for the study was for both the researcher and participants to share and learn from one another.

4.4.2 Classroom observations (Appendix 7)

4.4.2.1 Retention and revision strategies

This section explores the views of the eight selected teachers

From the theoretical perspective (concepts and theories relevant to the research topic) explored in Chapter 2 of this study, the researcher has discovered and identified some classroom practices, procedures, and discourse that positively impact retention and revision strategies from time to time. The researcher identified codes deriving from the ideas of meaningful learning, problem-solving, learner-centred education, and the DMT (deepening mathematical thinking) discussed in Chapter 2, which were mainly adapted from meaningful learning, the theory underpinning this study.

Meaningful learning means learning with deep and flexible understanding. Retention and revision strategies form meaningful learning (Mayer, 2002: 226). Meaningful learning results from learners' construction of knowledge and cognitive processes requisite for successful problem solving (Mayer, 2002:227). Problem solving refers to a mechanism of altering mathematical skills or knowledge to new and unfamiliar situations. Problem solving entails coming up with ways of reaching new and unfamiliar goals or finding ways to change a particular situation into a new situation or goal state (Mayer, 2002: 227). According to Schroeder and Lester (1989:33), teaching through or by problem solving means using problems to teach or develop important mathematical ideas. Learner-centred education refers to a dissemination of content to learners in an instructional setting where the learners have the paramount responsibility (Mascolo, 2009, as cited in Serin, 2018:164). According to the researcher, learner-centred education is an approach whereby the methods of teaching shift the focus from the teacher to learners. Learner-centred education provides classroom opportunities for developing critical thinking and problem-solving (Serin, 2018:164). Deepening mathematical thinking are the instances where learners are provided with opportunities to engage with mathematics, to be able to justify their solutions (Julie, 2011).

The researcher, therefore, identified five items or codes in action words namely probing understanding, sense-making, drive learning, exploratory/inquisitive discussions, and learner interaction as lesson components that should most likely occur with or lead these strategies to promote deep understanding or meaningful learning. Ostensibly, these are some of the components that will derive from the notions discussed earlier. The codes are classified into those that describe the teachers' usual routine and discourses found to positively impact retention and revision strategies in a mathematics classroom.

With the help of classroom discourses we're able to see how the teacher, students and subject matter interact and what the consequences look like for the learners. Teachers, learners and subject matter are only understood in relation to each other (Loef Frank et al, 2007:4). The codes are probing understanding, sense making, drive learning, inquisitive exploratory discussions and learner interaction. The researcher adapted *Probing understanding* from learner-centred approach, a model for intentional teaching of school mathematics in Julie (2013a) from 'deepening mathematical thinking' as well as the ideas of problem solving. *Probing understanding* means that the teacher allows learners to justify and explain their solutions and strategies are applied to obtain answers. *Sense making* was triggered by the ideas of the learner-centred approach, the notions of deepening mathematical thinking, 'Mathematical Objects Taught' from the model for intentional teaching, and problem solving means that teachers use explicit mathematical objects (Julie, 2013a). Such mathematical objects are for example mathematical conventions, concepts, and definitions, relationships between concepts, methods, axioms, symbolisms, and theorems. By *drive learning*, the researcher refers to arousing learners' interest and the use of learners' opinions as a starting point for classroom discussions. *Inquisitive discussions* mean that the teacher encourages discussions or arguments not interfered with by the teachers. *Learner interaction* is when a teacher permits and encourages learners to comment on other learners' contributions in class discussions. Drive learning, exploratory discussions, and learner interaction were mainly adapted from the learner-centred approach reviewed in chapter 2. All these above are derived and mainly adapted from meaningful learning, the theory underpinning this study.

In this section, the researcher selected some of the lessons excerpts that appeared best or were well presented compared to the other classroom observation lessons for each teacher, in terms of mathematics facilitation through retention and revision, also considering the codes discussed above. The researcher took the best excerpts for each teacher to give a fair perception about how Namibian senior secondary school mathematics teachers facilitate mathematics through retention and revision strategies in their classrooms. The researcher selected the particular excerpts lessons to give an insight as to what an extent Namibian teachers need to explore retention and revision strategies. The sample teacher-learner conversation depicted practice or actions to provide an insight into evaluating the eight observed teachers' lesson facilitation experiences versus their responses (perceptions) during the interviews. The main aim of these excerpts is for the researcher to present, analyse, and assess the teachers' classroom experiences regarding the facilitation of mathematics through retention and revision strategies as a means to meaningful learning while considering the incorporation of the necessary classroom practices or procedures, in an attempt to answer the main research question. Negotiation for entry to the teachers' classes took place as depicted in Chapter 3 of this study and the teacher used classroom observation notes (see 3.7.1.3, para. 3 & 3.11). The observation period was six weeks. All the teachers taught in English as a medium of instruction in Namibia. What follows below are some of the lesson extracts from the classroom observations.

4.4.2.1.1 Conversation samples between teachers and learners

School A

Teacher Bimboo (pseudonym)

Topic: **Trigonometry** (Angles of elevation and depression)

Table 4.3 depicts an extract of a classroom conversation that took place between teacher Bimboo and Grade 11 learners. The focus of the lesson was solving trigonometric problems in two dimensions involving determining the angles of depression, elevation and distances, a three-dimensional situation where they had to identify and use appropriate trigonometric ratios. The trigonometric problem given to the learners was to calculate the distance between two boats if the angle of depression for one boat is 16° and the angle of depression for another boat is 8°.

Table 4.3: Samples classroom conversation between teacher Bimboo (pseudonym) and Grade 11 learners

Teacher Bimboo	**Learners**
Let us discuss the Homework [from the previous lesson]. Who is coming to share the solution on the chalkboard with the class? Problem: A person sees two boats on the ocean from a lighthouse top of the height of 85m. The angle of depression for boat one is 16°, and for boat two is 8°. Find the distance between boat 1 and 2.	[everybody quiet]
What did you write in your books? That's what you should share; you don't have to be correct.	[silence]
Remember, from yesterday I told you that angle of elevation is an angle from the ground (horizontal) to the top, and, angles of depression is an angle from the top (horizontal) to the ground [making sketches on the chalkboard]; from the ground you look up, and from the top, you look down.	[listening and observing]
Hmm…, Okay, let's do it together. [Teacher Bimboo calculates the distance between the two boats and demonstrates solutions on the chalkboard.	[learners seated and observing the teacher]
Do we agree?	Yes, Ms.
Have you got it? Can I give you more exercise?	Yes.

Okay, copy the correction.	[copying the correction]

The teacher used sketches on the chalkboard. The sketches indicated some forms of visual mnemonics, a retention strategy for learners to memorize ideas about angles of elevation and angles of depression, as suggested by Hogue (2019:2). The homework comprised of a few problems about the same topic, that assure overlearning, a revision strategy (Rohrer & Taylor, 2006).

This particular lesson missed probing of understanding. She did everything on behalf of the learners. Such practices turn down learners' opportunities for mathematical exploration and collaborative knowledge construction (Manouchehri, 2007:299). Teacher Bimboo allowed learners to solve homework problems on the chalkboard as she indicated in one of her interview comments. The researcher has observed that the teacher tried to establish sense-making. Sense making means a teacher explicitly refers to mathematical formality (conventions), analogies (symbolism) definitions, and principles (axioms and theorems). By referring to mathematical conventions, theorems, and symbolisms associated with angles of depression and angles of elevation the teacher creates opportunities for learners to give meanings and interpret the ideas, thus the teacher establishes sense-making because learners give meanings. The teacher started off the lesson with the learners' ideas by asking them to share their opinions first. Using learners' ideas to start off lesson discussions indicated drive learning. Drive learning means the teacher uses learners' ideas to start off classroom discussions. The teacher ended the period by showing, and writing the solutions on the chalkboard while learners copy the corrections. The teacher moved on to introduce a brand new topic, 'angle properties', and introduced the properties one by one, using sketches, making notes immediately on the chalkboard while learners simultaneously listen and copy the summary into their workbooks. When the time was up, the teacher informed the learners that the lesson continues tomorrow and released the learners.

Teacher Bimboo (pseudonym)

Topic: **Trigonometry** (Three-figure bearings and reverse bearings)

Table 4.4 represents another dialogue between teacher Bimboo and grade 11 learners. The focuses of this lesson was three-figure bearings and reverse bearings as a direction of a point relative to another point and expressed as a three-figure number. Learners had to interpret and use three-figure bearings (i.e. indicate the sizes of angles from the north line of one point to the line connecting the two points, measured in a clockwise direction). The exercise given to the learners was to calculate three-figure bearings of points measured clockwise from the North (i.e. $000° - 360°$).

Table 4.4: Sample classroom conversation between teacher Bimboo (pseudonym) and Grade 11 learners

Teacher Bimboo	Learners
I see that some of you are struggling to find the difference between bearing and reverse bearing [teacher clarifies the difference by working out two problems on the chalkboard while explaining it to the learners].	Learners observe and listen.
Well, the good thing about mathematics is that only the values or numbers change, but rules in mathematics stay the same. Like I have always told you; e.g., find the bearing of **A** from **B** and vice versa, 1. Connect the two points with a straight line. 2. Draw the North line at the point following the word **from** in each case. 3. From the North, move in a clockwise direction until the line connecting the two points. That's the angle you need to find. The rules stay the same.	Okay, Ms.
Now let us do this one more time by doing this exercise individually. Paste the exercise paper in your workbooks and give your solutions just below it. [Teacher hands out the exercise papers with eight sums to the learners].	[Learners receive the exercise]
[Teacher walks row by row, checking what the learners were writing, and then repeats the rules over and over whenever she noticed the learners were writing a wrong answer].	[Learners complete the exercise individually].
Who wants to share the solutions on the chalkboard?	[Different learners share their solutions silently on the chalkboard].
[Ticking (for correct answers) and cross marking (for wrong answers)] Who wants to help with the wrong answers?	[Different learners solve the remaining sums quietly on the chalkboard].
Are the answers all correct now class?	Yes, Ms.
Copy the correction, then we meet tomorrow, it's time up.	Okay, Ms.

The visuals and phrases in the 3-steps rules depicted by the teacher in table 4.4 to make the idea more concrete and easy to remember are consistent with Bah et al. (2019:9) about loci techniques and model mnemonics (See 2.3.3.1).

Teacher Bimboo seems to agree with Hoque (2019:2), that ideas can be memorized in different ways and employing various strategies such as visualization, mnemonics. The repetitive non-problem-based or structured and the problem-based or open-ended problems given to the learners as an exercise demonstrated drill-and-practice (Van De Wale et al., 2010:69). This lesson comprised of a short set of repetitive activities on one topic and thus assured overlearning (Rohrer & Taylor, 2006).

Table 4.4 shows that the teacher has probed learners' understanding because as learners were doing the work individually in their exercise books and on the writing board; she was also giving individual attention asking them questions. But learners worked out solutions silently on the chalkboard. Teacher Bimboo incorporated some mathematical practices (conventions), theorems (axioms), and symbolisms related to bearings (sense-making). Learners' workings on the chalkboard resulted in some exploratory classroom discussions.

Teacher Lucia (pseudonym)

Topic: **Geometrical terms and angle properties** (Angle properties of parallel lines)

In this particular lesson on geometry learners had to interpret and use geometrical terms and properties to identify angles formed within parallel lines. Table 4.5 illustrates some of the discussion between teacher Lucia and her Grade 11 learners.

Table 4.5: Samples classroom conversation between teacher Lucia (pseudonym) and Grade 11 learners

Teacher Lucia	Learners
The teacher draws one pair of horizontal parallel lines on the chalkboard [without drawing arrows to indicate to the learners that they are parallel lines], adds one transversal, and named the angles formed within the parallel lines in order from a-h. Which of these angles are alternate angles?	C & f, Ms.
Correct! If you observe, you will see that alternate angles form a Z shape [uses an acrostic-like mnemonic]. They are therefore; also called Z angles [Teacher draws two pairs of Z shapes to form two pairs of alternate angles within the parallel lines]. Learner A also left out d & e. Do you agree with me class?	Yes, Ms.
So, Learner B, what is the angle rule?	They are equal.
Yes, they are equal [Teacher shows the	Yes, Ms.

learners on the chalkboard what is meant by 'They are equal' indicating and demonstrating on the chalkboard that all PAIRS are exactly the same size]. So, with pairs of alternate angles, all angles are the same?	

The 'Z' angle can be both a verbal and a visual prompt for remembering how to identify an alternate angle formed within parallel lines. Mnemonics were a retention or memorization strategy that featured in this particular lesson. The opinion of the researcher is that there is no evidence of revision strategies in this lesson. Teacher Lucia stated, 'learner A also left out d & e', without providing an opportunity for the learners to discover it on their own. Also, 'Yes' answers by the learners do not entirely indicate understanding. The teacher missed mentioning parallel line (parallelism). You can have 'alternate angles.' They are only equal because of parallel lines.

Teacher Lucia made use of some other mathematical conventions, axioms, and symbolisms related to angles formed within parallel lines in terms of the rules she explained to the learners. Teacher Lucia also started the lesson discussions by posing some questions to the learners, to start off the lesson discussions with the learners' ideas; the researcher finds this to be intentions for drive learning (i.e. the learners drive learning). The teacher checked and used the learners' existing knowledge (what the learners already know).

As suggested by the learner-centred approach, it is recommended that learners drive the learning process in classrooms. During the interview, teacher Lucia said she presented problems for learners to solve them on the chalkboard and give them opportunities to ask questions but it did not happen in this particular lesson. Learner-centred education contributes more to meaningful learning than teacher centeredness. Learner-centred education provides opportunities for learners to engage and evaluate their own learning, especially through teaching each other and answering questions from peers. In this way it contributes more to deep understanding retention. Similarly, the teacher continued with 'F pattern' (Corresponding angles rule; equal), the 'C/U pattern (Co-interior angles rule; add up to 180°) and 'Opposite/Vertically opposite angles rule (congruent/equal). The teacher somehow denied learners the opportunity to explore and spot all the Z shapes (pairs of alternate angles) or to allow the learners to describe the angles in other ways, but instead, she did almost everything on their behalf.

The teacher's references to F, Z, C angles, and parallelism aid in 'retention' and 'revision' as visual and verbal prompts to make it easy for the learners to remember angles formed within parallel lines, which ensures mnemonics (DeLashmutt, 2007). Reminding learners about these has to do with assisting 'retention' and is related to the 'forget problem'. However, we all differ at times when it comes to saying and doing; this excerpt was just for one specific lesson.

Teacher Zimkitha (pseudonym)

Topic: **Algebra** (revision lesson: algebraic expressions, algebraic linear equations and changing the subject of a formula)

The focus of this lesson on Algebra revision involved expanding, simplifying linear algebraic expressions (i.e. multiplying monomials or binomials by binomials and polynomials) and manipulating of algebraic fractions. It incorporated solving linear equations, quadratic equations, linear inequalities and changing the subject of the formula. Table 4.6 portrays a discourse between teacher Zimkitha and grade 12 learners.

Table 4.6: Samples classroom conversation between teacher Zimkitha (pseudonym) and Grade 12 learners

Teacher Zimkitha	**Learners**
After concluding this chapter, I have noticed that the challenge you're experiencing now is confusing the signs when dealing with positive and negative numbers in algebraic expressions, equations, inequalities and changing the subject of a formula.	True Ms, Yes Ms [Some learners].
Let us look at these sums. [Teacher copies 5 sums on the chalkboard]. 1. Simplify: a) $(2x + y)(2x + 3y)$ b) $x^3 (x + 1) - 2x^2 (a - 1)$ c) $\frac{b+2}{36b^2} - \frac{b-3}{63b} + \frac{2}{18}$ d) $6(a + 1) = 4 (10 - 2a + 2)$ 2. Solve for x and y ; $(5x - y)^2 + (x - 3)^2 = 0$ 3. Solve for x; $3(-4x + 20) \geq 20$ 4. Make c the subject of the formula: $a = \frac{1}{b} - \frac{c}{d}$ [The teacher calls out two learners who raised their hands, to try solving the first sum on the chalkboard].	Two learners solved the first sum on the chalkboard.
Class, which of the answers here is correct?	Learner A, Learner B [different learners say

	different answers; Yes, No].
Ok. Please listen! [Teacher starts talking, explaining and demonstrating all the solutions on the chalkboard].	Learners listen passively and attentively to the teacher.

The teacher used a 'distributed practice' also, referred to as 'spaced practice' as a revision strategy to revise with the learners as practice problems were not only on one topic (Rohrer & Taylor, 2006). The different topics (i.e. algebraic expressions, algebraic linear equations and changing the subject of a formula) were distributed over this lesson. Research has shown that because of the spaced or distributed effect, this strategy increases the chances of good achievement scores. The researcher picked it up during the demonstration that the teacher could not give an explanation or emphasize why one flips the signs when collecting like terms and when dividing or multiplying with negative values for linear equations and inequalities, to help learners not to forget to flip the signs. For example, when one has to multiply or divide the left- and right-hand sides by any negative value, she/he must flip the signs to avoid making the smaller value greater than the actual big one as the larger number gains a higher negative value. For example, imagine comparing $6 > 2$. Then multiply both sides by -1; $6\,(-1) > 2\,(-1)$. That is now $-6 > -2$ which is incorrect and thus the sign of this inequality must be flipped. So, there was minimal evidence of sense-making in the lesson.

In this particular lesson, the teacher did not investigate learners' understanding, because she did not ask learners why they solved the problems the way they did, nor even comment when she noticed that the learners' answers were wrong. Instead, she started to provide answers. Providing learners with environments that reinforce learners' ability to motivate and justify their solutions teach learners that struggling is part of learning mathematics ('disposition of productive struggle') (Julie, 2011). Struggling and making errors and figuring out why learners made the mistakes they did are a crucial part of learning (Stigler & Hiebert, 1998:3).

The researcher believes that, checking if learners understand helps with identifying misconceptions, should there be, which inform teaching for understanding. The teacher demonstrated an intention to use learners' ideas as a starting point for the discussion even though in the end, she could not use the learners' ideas or existing knowledge. Based on learner-centred education when learners drive learning, it contributes more to meaningful learning and retention. There was minimal evidence of exploratory learner discussions and interaction; there were not many discussions between the teacher and the learners and learners with each other. Teachers should provide opportunities where learners passionately explore mathematics and engage in collaborative knowledge construction (Manouchehri, 2007:299). During the interview, teacher Zimkitha stated that *'I'm a type of 'practice makes perfect,' so I let my learners do lots of practice'*. According to table 4.6 teacher, Zimkitha's statement seems to conflict with what happened during this lesson. However, this was just an extract from one of the lessons.

Teacher Khosi (pseudonym)

Topic: **Trigonometry** (previous lesson's work: Trigonometric Equations)

The lesson focus was on trigonometric equations in Grade 12. The learners had to solve trigonometric equations and use the CAST diagram. Table 4.7 shows some of the teacher Khosi's lesson scenario.

Table 4.7: Sample classroom conversation between teacher Khosi (pseudonym) and Grade 12 learners

Teacher Khosi	Learners
That is how we work out the value of y based on the CAST diagram.	Yes, Sir.
Now to find α in the equation $4\ \mathbf{tan}\ \alpha - 4 = 2\ \mathbf{cos}\ 45.2°$ for $0° \leq 360°$, $4\ \mathbf{tan}\ \alpha = 2\ \mathbf{cos}\ 45.2° + 4$ Take 4 to the right-hand side $4\ \mathbf{tan}\ \alpha = 5.40926842$ Enter in the right-hand side on your calculator $\mathbf{tan}\ \alpha = \frac{5.40926842}{4}$ ÷ by 4 on both sides because there must be one in front of tan (ratio) $\mathbf{tan}\ \alpha = 1.352317105$ The equation is now in the basic form Are we together? [Teacher explains everything while writing on the chalkboard]	Yes Sir.
Draw your lines for the positive tan on the CAST diagram [The teacher draws and demonstrates the lines where tan is positive on the chalkboard] **SHIFT** [Second Function], tan, $1.35 = 53.5°$ Use your calculator to find the key angle $\alpha = 53.5$ Or $\alpha = 180° + 53.5°$ Then work out the value of x based on the CAST diagram. $\alpha = 233.5°$ Are we together? [Teacher explains, demonstrates everything while writing on the chalkboard]	Yes, Sir
Okay. Copy.	Okay, Ms.

Retention strategies involve classroom or lesson activities that use cognitive procedures of *recognizing* and *recalling*, where the goal of instruction or teaching is to promote memory retention (Mayer, 2002: 232). Revision strategies entail lesson tasks that require cognitive procedures *Understand*, *Apply*, *Analyse*, *Evaluate*, and *Create* intended to develop and promote transfer (Mayer, 2002: 232). Table 4.7 shows that the teacher used a retention strategy, for example the mnemonic CAST, a verbal prompt and the CAST diagram, a visual prompt to help learners remember the trigonometric functions signs in each of the four quadrants when solving trigonometric equations.

Even though the teacher appeared to dominate the class because she did not pose questions to the learners to probe or investigate understanding and the learners were not involved at all, she made some effort to develop sense-making by referring to some mathematical conventions, axioms, and symbolism in the case of solving the trigonometric equation. The researcher could not pick up any exploratory discourses or learner interaction in this lesson. Teacher Khosi also suggested ideas of group work in the interviews, even though they could not feature in this specific lesson. However, group work is not a teaching strategy that teachers can use every day. This vignette was only for one specific visit.

School B

Teacher Freddy (pseudonym)

Topic: **Analytic Geometry**

The lesson focused on Analytic Geometry. In this lesson the discussion was a correction on classwork turned homework from the previous day. The problem given to the learners was to use analytical methods to prove whether AB is parallel to CD and QR is perpendicular to ST on a four-sided plane figure.

Table 4.8: Samples classroom conversation between teacher Freddy (pseudonym) and Grade 11 learners

Teacher Freddy	Learners
Well, how do we prove that AB//CD and QR⊥ST	You must find the gradients of all the lines first [Some learners shouted].
Then, what should we do from there on?	If the gradients are the same it means the lines AB and CD are parallel. If you obtain -1 after multiplying the two gradients then it means the two lines are perpendicular
Correct! [Teacher demonstrates all the calculations on the writing board and finds the gradients of all the lines]. Do we agree?	Yes, Sir.
Well, we have all observed that the gradients of AB and CD are the same so we conclude by writing that $M_{AB} = M_{CD}$ ∴ AB //CD.	Yes, Sir.
You know, we have to write $M_{QR} = \frac{6}{9}$ in its	Yes, Sir.

simplest form.	
Now let us test if $M_{QR} \times M_{ST} = -1$ [Teacher demonstrates all the calculations on the writing board].	Yes, Sir.
Do we agree?	Yes, Sir.
Then we also conclude for QR and ST and say QR⊥ST [Teacher writing on the chalkboard].	Yes, Sir.

The teacher used verbal prompts enhancing the learners' remembering strategies. For example, teacher Freddy ended the conversation by saying lines AB and CD are parallel because their gradients are equal and lines QR and ST are perpendicular because their gradients' product equals to -1; these assure mnemonics. The revision strategy demonstrated by teacher Freddy was the classwork. The class activity discussed appears to portray overlearning and practice because it was a short piece of practice work focused on one topic. Overlearning, in opposition to the massed practice, refers to dividing or spreading similar practice problems across two or more sessions. Massed practice means an accumulation or a collection of related practice problems in one assignment or practice session (Rohrer & Taylor, 2006). Practice refers to a distribution of different problem-based activities or tasks over numerous class periods each addressing or representing the same basic concept or objective (Van De Wale et al., 2010:69). The teacher made an effort to establish drive learning by starting off the discussion with the learners' ideas. The learner-centred education suggests that learners' ideas should drive the learning process in a classroom. The teacher also referred to some mathematical conventions or rules, symbolisms (analogies), and principles related to parallel and perpendicular lines.

Teacher Awino (pseudonym)

Topic: **Analytic Geometry**

This lesson was on geometry. The focus of the lesson was using geometrical properties of quadrilaterals and analytical methods to prove whether quadrilateral ABCD is a trapezium or not.

Table 4.9: Samples of a classroom conversation between teacher Awino (pseudonym) and Grade 11 learners

Teacher Awino	**Learners**
Well, we need to prove whether quadrilateral ABCD is a trapezium or not.	Yes, Sir.
We have to use analytical methods, so we must know its properties.	Yes.
We know that one pair of sides is parallel	Yes.

[making a sketch on the chalkboard]. Is that so? Opposite sides, remember.	
This means we can prove whether ABCD is a trapezium by finding the gradient of the four sides.	Yes.
Do we agree?	Yes, Sir.
Let us work out the gradient of AD.	$\frac{3}{4}$ [One learner shouts the answer]
Is that correct class?	Yes, Sir. [Class]
James (pseudonym), come and show your working on the chalkboard. Can I have three more volunteers to write their solutions on the board?	[James (pseudonym) and the three other learners write the solution on the board quietly.]
Class, what do you say about their solutions?	James (Pseudonym) is correct sir. [Class shouts].
What is our conclusion then?	It is a trapezium.
Why?	Because AD and BC have same gradients.
Yes. Because two pairs of sides have the same gradients. What does that mean?	They are parallel.
Therefore, it is a trapezium because one pair of opposite sides is parallel.	Yes.
This is your homework. [Teacher hands out an activity to the learners]	Okay, Sir.

Teacher Awino used visualizations (mnemonics), a retention strategy, as he was illustrating the properties of a trapezium on the chalkboard. Visualization is one of the various ways and strategies that ideas can be memorised (Hoque, 2019:2). The teacher incorporated practice, a revision strategy, by asking learners to solve an analytical problem on the chalkboard. Practice refers to spreading similar problem-based activities or experiences over a number of class periods (Van De Wale et al., 2010:6 9).

The researcher noted that the teacher showed awareness that learners should be provided with opportunities to give justification to their solutions and reasoning. Though the teacher seemed to have dominated the discussions at times, he asks 'what' and 'why' questions as a way of probing understanding. He also referred to some mathematical conventions and axioms when he was demonstrating how to find the gradients, and established some mathematical symbolisms or analogies for comparing the gradients; that is a good way of developing sense-making. Table 4.9 also shows some evidence for exploratory discourses and interactional discussions because various learners under the guidance of the teacher solved some problems on the chalkboard (exploratory discussions) and commented on each other's answers (learner interaction). During the interview, teacher Awino stated that he encourages his learners to work together, which the researcher thinks actually happened in his class.

Teacher Angelo (pseudonym)

Topic: **Mensuration** (Area and perimeter of a circle)

Table 4.10 depicts a conversation between teacher Angelo and his Grade 12 learners. The lesson focus was circumference and area of a circle, including how to logically come to the formulas for calculating the area of a circle.

Table 4.10: Samples classroom conversation between teacher Angelo (pseudonym) and Grade 12 learners

Teacher Angelo	**Learners**
The teacher divides learners into groups of 6 learners and hands out worksheets with a diagram of a circle that was divided in 12 equal sectors. 'What do you think we are discussing today'?	Perimeter of a circle, circumference of a circle, area of a circle [learners raised up their hands at random and shared their opinions with the class].
You're all correct but for a circle, the term circumference is mathematically correct and not the perimeter. What is the formula for calculating a circle circumference?	Learner x writes down the formula correctly on the chalkboard.
It is correct. Today we are discussing circumference and area of a circle. [Teacher hands out scissors and glues and instructs the groups.] Cut out the sectors of the circle and arrange the sectors to form a parallelogram shape of this study. [Teacher added, we will understand the shape of the circle better when we transform its shape into a parallelogram]	Ok, Sir [In groups learners did as they were instructed, facilitated by the teacher].
In your groups discuss and illustrate how you would arrive at the formula to calculate the perimeter and area of that parallelogram. Let the group leaders copy your opinions on the chalkboard.	Learners worked in their groups. Group leaders copied their ideas on the chalkboard.
Class, which of the ideas presented on the chalkboard is correct for each formula (Circumference and Area)? Give reasons for your answers.	[Learners' discussions, debates, arguments, and interactions].
The teacher rules out the wrong answers and explains the correct answers on the chalkboard (The teacher's explanation was more or less as in Chapter 2, 2.3.2.4, fig.2.6). [Only one group was close to the correct solution].	Learners listened and asked the teachers some questions. Some learners defended their answers that were ruled out by the teacher and other learners.

The teacher indicated visualizations (visual prompts) as a mnemonic to help learners with remembering strategies using worksheet. A revision strategy featuring in this lesson is ‘deepening mathematical thinking’ in this lesson. DMTs are experiences where learners have opportunities to interact with mathematics work that reinforces deep understanding, ability to justify solutions, and reflect on their work (Julie, 2011). Learners engaged with mathematics (Julie, 2011). Teacher Angelo also seems to be in agreement with the constructive ideology of Doerr and Lesh (2003:212) that learners cannot passively ‘receive’ knowledge from the teachers, but knowledge is ‘constructed’ actively by learners.

Learners were actively involved throughout teacher Angelo’s lesson; a way to help learners deepen their mathematical thinking and recall what they were taught easily. The opportunities for struggling created in this lesson teach learners that struggling forms part of mathematics learning, a ‘disposition of productive struggle’ (Julie, 2011:2). The researcher believes that allowing learners to learn from their mistakes plays a role in learning mathematics. Struggling, making mistakes, and figuring out what informs a learner’s mistake is the key part of the process of learning (Heibert & Stingler, 1998:3).

Learners were granted opportunities to construct their own meanings at all possible times in teacher Angelo’s class by doing more. Teacher Angelo also allowed learners to work together in groups which provided opportunities where learners passionately explore mathematics and engaged in collaborative knowledge construction (Manouchehri, 2007:299). The teacher could pose questions like ‘what’, ‘how’ and ‘why; this provided the learners with chances to justify their responses. Therefore, the activity given by the teacher allowed him to probe understanding. The teacher also referred to mathematical conventions, axioms, and symbolisms related to area circumference which assisted learners to make sense of the formulas for circumference and perimeter. Furthermore, the teacher aroused the learners’ interest by asking the learners to guess the topic of the day and used some of the learners’ opinions to begin discussions as required for drive learning. Table 4.10 shows evidence for discussions with the teacher and other learners (discussions and exploratory discussions) as well as interactions by learners with other learners (learner interactions). The activity also provided an opportunity for exploratory discussions and learner interactions.

Teacher Angelo concluded the conversation by stressing that during the next period the learners would do the same task individually and hand in individual work. The researcher thinks that this was thoughtful of the teacher because learners are pressured to go and practice what they were taught, especially that the task was really done during the next lesson. This is another way on its own to deal with the ‘forget problem’.

The researcher believes that the way this teacher presented this lesson would also make it easy for the learners to learn with understanding when they would be learning about the circumference and area of a sector of a circle and surface area of cylinders or combination figures.

This teacher's lesson presentation might not be the best, other teachers could approach the same content in different ways, but the researcher believes that this teacher, for this lesson in particular, did not just transmit knowledge but facilitated and provided an experience for learners to learn (Milan, 2000:26).

Teacher Angelo (pseudonym)

Topic: **Trigonometry**

Table 4.11 illustrates a conversation between teacher Angelo and Grade 12 learners. This was an introductory lesson. The lesson discussion focus was how to apply the theorem of Pythagoras and the sine, cosine and tangent ratios for acute angles, and to calculate sides or angles of right-angled triangles. The lesson also involved how to determine and use appropriate trigonometric ratios to solve trigonometric problems including angles of depression and elevation.

Table 4.11: Samples classroom conversation between teacher Angelo (pseudonym) and Grade 12 learners

Teacher Angelo	**Learners**
Today we are starting with Trigonometry [teacher introduces the topic by writing it on the chalkboard].	Learners silently listening.
So. What is Trigonometry?	It's about angles, Sir.
What else can we say? That's not enough for me.	It's about angle sizes.
What more is it about?	Also triangles, Sir [some learner]
You all are correct! Why? Why are you saying it's about angles, why are you saying it's about triangles?	[Class mute]
Trigonometry is the relationships or connections between sizes of angles as well as the lengths of sides of triangles.	Oh, yes, Sir [class].
Trigonometry is a word that originated from two Greek words, trigonon (triangle) and metron (to measure).	Oh, okay, Sir.
Firstly, we have $90°$ Triangles and Non $90°$ Triangles [writing and drawing the two sketches on the chalkboard].	Yes, sir.
Let's begin with the $90°$ (right-angle) Triangles. [Drawing a labeled sketch, with given angle, sides and descriptions of sides; Opposite (O) - side opposite given/marked angle, Hypotenuse (H) - side opposite right	[Some learners listen while some are copying and making notes into their work books].

angle, Adjacent (A) – the side next to the given angle].	
How do we name the angles right?	Based on the angle that is given.
Correct! You name the sides from the given angle, very important.	Yes, sir.
There are Three Ratios to remember before you go on. It is very important. $\sin x = \frac{Opp\ (O)}{Hyp\ (H)}$ $\cos x = \frac{Adj\ (A)}{Hyp\ (H)}$ $\tan x = \frac{Opp\ (O)}{Adj\ (A)}$ [writes on the chalkboard] To remember it we memorize the word?	SOH CAH TOA! [Class shouts]
Yes! **<u>S</u>OH <u>C</u>AH <u>T</u>OA** [underlines and bolds on the chalkboard]	Yes, Sir.
Two more things that are very important to remember when you work on problems related to sizes of angles and lengths of sides of triangles. When finding the side; ➢ Given 2 sides (use Pythagoras' Theorem) ➢ Given 1 side and 1 angle (choose the correct ratios) When finding an angle; ➢ Given two sides to find an angle (use the ratios)	Yes, Sir.

Visualizations (visual prompts) are mnemonics and the memorization strategies featuring in this lesson. The teacher used visualizations by illustrating various sketches of angles and triangles. SOH CAH TOA is a popular mnemonic in secondary school mathematics that this teacher used during the lesson. There is no evidence of a revision strategy in this lesson; however, this was an introductory lesson.

By asking 'what' and 'why' questions, the teacher also attempted to probe and establish understanding. Furthermore, teacher Angelo showed awareness of the need to drive learning for firstly, he attempted to retrieve, acquire, and use the learners' existing knowledge to start off the lesson discussion. He also made an effort to develop sense-making by referring to some appropriate mathematical conventions (e.g. the origin of the word trigonometry), axioms (e.g. the trigonometric ratios), and symbolisms such as the analogies employed during the lesson to solve problems related to the lengths of sides and angles. There were also demonstrations of exploratory or inquisitive discussions in the lesson though the teacher to some extent dominated the lesson and there was no learner interaction.

Teacher Idaresit (pseudonym)

Topic: **Mensuration** (Area and perimeter of a circle)

Table 4.12 shows a discourse between teacher Idaresit and Grade 12 learners. The focus of the lesson was circumference and area of a circle.

Table 4.12: Samples of a classroom conversation between teacher Idaresit (pseudonym) and Grade 12 learners

Teacher Idaresit	**Learners**
Today we are discussing circumference and area of a circle.	Listen.
Well, who wants to volunteer to write the formulas for calculating circumference and for the area of a circle on the chalkboard? [Teacher calls out learners at random].	[Two Learners write the two formulas correctly on the chalkboard]. C= $2\pi r$ $A = \pi r^2$
You're all correct! [Teacher starts to write while explaining one example each for circumference and area on the chalkboard, sketching a circle with a radius of 5 cm]: Circumference of a circle $C = 2\pi r$ $= 2(3.142)(5)$ $= 31.4\ cm$ Area of a circle $A = \pi r^2$ $= (3.142)(5)^2$ $= 78.6\ cm^2$	Learners listen.
Do we understand?	Yes Ms.
Okay. Copy the notes.	Okay, Ms.
Now you can check out on page 234 of the textbook for more examples and do Exercise 9. a-b, 10. a-b, as well as exercise 1. Number 1. a-e in your workbooks.	Learners start to do the exercises individually in their workbooks.

This lesson ended when the bell rang while the learners were still busy. The teacher dismisses the learners and tells the learners that the exercise becomes homework. The retention strategies used by teacher Idaresit in this lesson was drill.

Drill refers to learners imitating theories, examples, or ideas and doing repetitive non-problem based or structured questions intended to improve a skill or procedure already taught (Van De Wale et al., 2010:6 9). Knowledge acquired over drill-and-practice is without depth and inflexible for other related unfamiliar situations (Wertheimer, cited in Schoenfeld, 1987:3). The revision strategy featuring in this lesson was practice and the specific was massed practice because a lot of practice questions and problems were collected in one set. Practice means learners working on different problem-based or unstructured tasks, activities or experiences addressing the same concepts spread over class periods (Van De Wale et al., 2010:6 9). Massed practice implies that similar practice problems are collected in one practice session (Rohrer & Taylor, 2006). The teacher started off and used learners' ideas. According to the learner-centred approach, when learners' ideas drive learning, learners do more, which helps with retention because ordinarily people remember better what they already know compared to what they did not know or new ideas.

Table 4.13 Summary of the teachers' selected classroom observation lesson extracts on retention and revision strategies

	TEACHERS							
	SCHOOL A				**SCHOOL B**			
	Bimboo	**Lucia**	**Zimkitha**	**Khosi**	**Awino**	**Freddy**	**Angelo**	**Ida**
RETENTION STRATEGIES								
RETENTION STRATEGIES								
Visualizations	✓	✓			✓		✓	
Mnemonics	✓	✓		✓	✓	✓	✓	
Drill-&-Practice	✓							✓
Advance organizers								
Rote learning								
REVISION STRATEGIES								
Massed practice								✓
Overlearning	✓				✓	✓		

Exam-Driven-Teaching								
Distributed practice			✓					
Productive practice: Spiral revision Deepening Mathematical Thinking								
							✓	

The section above explored the eight participants’ experiences on the problem of forgetting to answer the main research question: How do Namibian senior secondary school mathematics teachers perceive and experience the facilitation of mathematics through retention and revision strategies? The teachers seemed to have plenty of revision and retention strategies based on the interviews. However, the same teachers are still experiencing challenges using retention and revision strategies in their classrooms.

The researcher also observed that the eight selected teachers’ teaching orientation was more dominated by a lot of talking and showing by the teachers while the learners listen attentively. Through the literature review, the researcher discovered that when retention and revision strategies are applied, learners are supposed to do more. The researcher believes that the teachers are capable of doing better than what they are currently doing in terms of retention and revision strategies. Throughout the observation process, the researcher observed more leading questions with most teachers’ lessons than probing questions. The teachers from time to time, with minimal learner involvement, used explicit mathematical objects, drive learning, exploratory discussions, and learner interaction most of the time.

However, these five components to be incorporated in one lesson require a greater deal of time than the 35-40 minutes of teaching time per lesson, learners’ rotation between classes included. Furthermore, not all strategies can be used every day. Time constraints are one of the challenges facing the teachers in this study’s results and might have impacted the teachers’ lesson preparations and teaching. The classroom observation checklist sheets (See Appendix 7) for the teachers were analysed by the researcher by identifying the strategies used by the teachers. The results showed that teachers have utilised some of the retention and revision strategies during the classroom class observations, apart from ‘productive practice’, and ‘spiral revision’ and ‘deepening mathematical thinking’ now and then. Somehow little of what the teachers advocated in the interviews and questionnaires transpired in their classrooms (for the eight teachers). None of the teachers did ‘productive practice’ sets of activities with their learners.

As stated earlier, from the face-to-face interviews and questionnaires, the researcher also wanted to find out about the retention and revision strategies that Namibian teachers say they use and compare what they say to what happens in the actual classroom situation. The table below illustrates the findings obtained during the entire classroom observations process per teacher, per school and not based only on the excerpts discussed above. The table analyses and thus intends to answer the main research question: How Namibian senior secondary school mathematics teachers perceive and experience retention and revision strategies in their teaching?

In Table 4.14 below, the researcher ends the classroom observations analysis by presenting and discussing the use of retention and revision strategies by Namibian teachers per teacher, per school, identifying emerging themes (retention and revision strategies) across schools for the whole observation period of one month in an attempt to answer the main research question. The researcher used the classroom observation notes and the checklist (Appendix 7) to achieve this goal.

Table 4.14: Summary and discussions of classroom observations period on the retention and revision strategies used by the teachers

School	**Teachers (pseudonyms)**	***Retention strategies***	***Revision strategies***	***Overlaps between retention & revision strategies*** *(See 2.3.1 -2.3.2)* *(See 2.4)*
A	Bimboo	-Mnemonics -Drill-and-practice	-Massed practice -Overlearning	***Retention strategies*** **Mnemonics** and **drill-and-practice** have overlapped for: -covering cognitive processes associated with *'retention'* or recalling (Mayer, 2002: 228-232): -Provide visual stimulation. -entail training (repeated practice) (e.g. Hoque, 2019:1; Kindt, 2011:137). -require binding or sticking information to the memory (memorization). -involve memory driving strategies for improving
	Lucia	Mnemonics Drill-and-practice	-Massed practice -Overlearning	
	Zimkitha	-Mnemonics -Drill-and-practice	-Massed practice -Overlearning Distributed practice (revision lesson)-Exam-Driven-Teaching	
	Khosi	-Mnemonics -Drill-and-practice	-Massed practice -Overlearning -Exam-Driven	

			Teaching	memory ability (Bih et al., 2019: 93-94). -Ease memory, enhance memory intake, reduce stress and broaden memory scope (Bih et al., 2019: 93). -Add value to insight required for solving non- problem-based, and problem-based activities (Hoque, 2019:1; (Kindt, 2011:137; Van De Wale et al., 2010:69, Kindt, 2011:137). ***Revision strategies*** -'Massed practice', 'overlearning, distributed practice and Exam-Driven Teaching have overlaps for involving cognitive processes associated with *'transfer'*. -'massed practice' and 'overlearning' are similar in a way that they are both about similar practice problems (problems are not focused on one idea or topic only) (Rohrer & Taylor, 2006). -'Distributed practice' is complementary to massed practice. In other words, distributed practice and massed practice are similar in a way that the sum of the practice problems is constant (Rohrer & Taylor, 2006). -'Distributed practice' is also similar to 'overlearning' in a way that exercise problems are distributed over sessions
B	Freddy	-Mnemonics -Drill-and-practice	-Massed practice -Overlearning	
	Awino	-Mnemonics -Drill-and-practice	-Overlearning -Exam-Driven Teaching	
	Angelo	-Mnemonics -Drill-and-practice	-Overlearning Distributed practice (mostly during tests) -Exam-Driven Teaching	
	Idaresit	-Mnemonics -Drill-and-practice	-Massed practice -Overlearning -Exam-Driven Teaching	

				(Rohrer & Taylor, 2006). -Exam-driven teaching have overlaps with drill-and-practice for involving problem-based and non-problem-based activities (Van De Wale et al., 2010:69). Exam-driven teaching is also similar to distributed practice for covering a variety of ideas or topics (Rohrer & Taylor, 2006).

The table showed that the retention strategies used by the teachers are some mnemonics and drill-and-practice. Therefore, the table indicates that none of the teachers used any of the other retention strategies narrated in the literature review (see 2.3.1), during the whole period of the researcher's classroom visits. The revision strategies observed from the teachers are massed practice, overlearning, distributed practice and exam-driven teaching (See 2.3.4).

Through continuous comparative procedure (the constant comparative method) described in Chapter 3, the researcher identified that the number of years of teaching experience does not always matter but mostly matter. The researcher can claim this statement after constantly comparing the teachers who were selected for classroom observations per grade level per school. The claim above has manifested in the comparisons through the entire observed teachers' views from the interviews and real-life classroom presentations, especially in the cases of teacher Angelo and Idaresit (Grade 12, school B), teacher Awino and teacher Freddy (Grade 11, school B), and teacher Zimkitha and teacher Khosi (Grade 12, school A). The teachers with more years of teaching experience expressed and demonstrated more retention and revision strategies that are more effective. Except for teacher Bimboo and teacher Lucia, the number of years of teaching experience did not seem to affect the results. In the same manner, the results have showed that the level of educational qualification or background does matter, especially through constantly comparing the results for teachers Awino and Freddy (Grade 11, school B), and Zimkitha and Khosi (Grade 12, school A). The researcher can claim the same statements above for the learners' test results discussed in the next section below.

4.4.2.2 Learners' test (instrument /transcripts Appendix 11)

As stated in chapter 3, after the selection of research subjects, the researcher pre-evaluated both classes by giving the same pre-test and then allowed both teachers of the same grade level to teach the same topic. After classroom observations, the researcher set down the teachers to reflect on their lessons. During the first week of classroom observations, the researcher intentionally identified the teachers observed to be using more explicit retention and revision strategies. The researcher chose one participant from each pair, as there were two participant teachers per grade for each school. The researcher in this process switched from a non-participant to a participant-observer by sharing some of the revision strategies found most effective according to the explored theoretical framework in Chapter 2. As stated before, the researcher shared some of these strategies with the identified participants only (the participants whose learners were exposed to more explicit retention strategies), who then applied it themselves with their learners.

The chosen or identified teachers whom the researcher shared some of the strategies with were teacher Bimboo, Zimkitha, Angelo, and Awino. However, both classes got identical post-tests set by the researcher after the conclusion of the topics, given after two weeks of observations. The second post-tests were taken at the end of the sixth week of classroom observations after the learners got exposed to a completely different new topic. That makes the non-trivial retention interval (RIs) of two and three weeks between the first and the second post-tests, according to Rohler and Tylor (2006). The non-trivial retention interval (RI) is the time interval between the latest learning/teaching session and the test (Rohler & Tylor, 2006).

As stated earlier, the researcher purposively chose two teachers for each grade (Grades 11 & 12) for each school, and each pair taught the same topics. As stated in Chapter 3, the activities (assessments) are part of the curriculum (teachers' schemes of work & syllabi). Also, the topics taught by the teachers were not those that the researcher chose or that the teachers felt more comfortable teaching but based on how far they have covered the schemes of works in place. It is not something that was developed by the researcher for the research. The study did not in any way interfere with the teaching and learning procedures at the schools.

The data presented below represents the empirical data of the pre- and post-tests results. As stated earlier in the methodology chapter (see 3.7.2.5), the stats were not the study's unit of analysis, but the researcher went the extra mile to see whether retention and revision strategies work or not. The researcher compared the results to check whether the learners who had explicit retention and revision strategies retained more, compared to the learners who were not. The researcher used the class average to represent the findings of the evaluation.The graphs show the performance of the respective classrooms:

School A

Grade 11

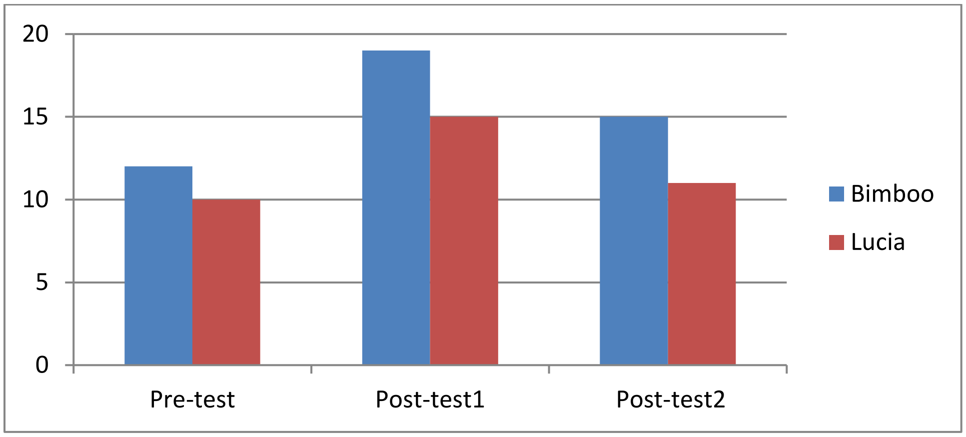


Figure 4.1School A, Grade 11 test results

The graph shows that there was an improvement in retention for both teacher Bimboo and teacher Lucia's classes. However, more learners retained more when it came to teacher Bimboo's class. This graph also validates that even though teacher Bimboo was one of the teachers whom the researcher shared some retention techniques with as a participant-observer, and the researcher's involvement at some point might have contributed to the learners' grades, her class seemed to have been initially exposed to more explicit retention and revision strategies compared to teacher Lucia's. This is because not only in all the delayed tests did the learners in teacher Bimboo's class outperform the other class, but during the pre-test too.

Also, the difference by which the average has increased from the pre-test to the first post-test is greater for teacher Bimboo's class. On the other hand, the graph shows that learners' retention decreased with time. It also shows that the difference with which the average has dropped is more for teacher Bimboo's class than teacher Lucia's. However, it still indicates that teacher Bimboo's class outperformed the other class. This, therefore, shows that if retention strategies work and if they are used as much as possible and effectively, learners' retention can be improved.

As shown in the teachers' profile, both teachers have the same qualification. This shows that the qualification does not count all the time. Teacher Bimboo also has fewer years of mathematics teaching experience compared to teacher Lucia. The results above, therefore, reveal that the number of teaching experience does not always count even for teachers with the same qualification.

Grade 12

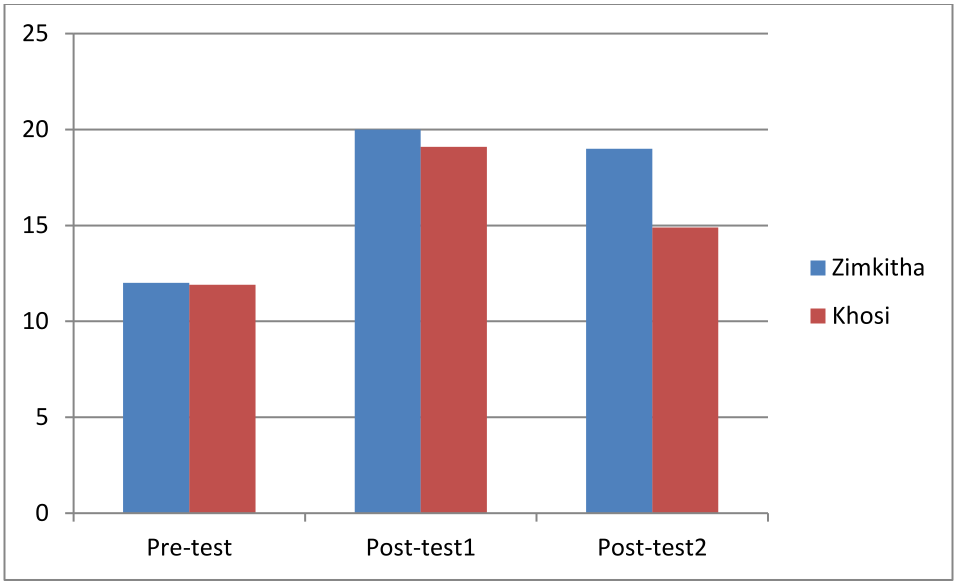


Figure 4.2 School A, Grade 12 test results

The graph above shows that there was an improvement in retention for both classes. There was however a slight difference in retention between the two classes during the pre-test. However, more retention is shown for teacher Zimkitha's class. Considering the pre-test results, this graph also shows that despite the fact that teacher Zimkitha was one of the teachers who at some point after the pre-tests happened to work in collaboration with the researcher as a participant-observer, her class shows evidence of previous or existing exposure to more explicit retention and revision strategies compared to teacher Khosi's. The rate of retention from the pre-test to the post-test was more or less the same for both classes.

On the other hand, this graph also shows that learners' retention dropped with time for both classes. However, it shows that the rate at which retention has dropped from the first post-test to the second post-test is much less for teacher Zimkitha's class compared to teacher Khosi's. For teacher Zimkitha, learners' retention dropped too, but it was not that significant s change. This shows that effective teaching retention and revision strategies could improve learners' retention in the senior secondary school mathematics classrooms.

As indicated in the teachers' profile, the qualification for teacher Khosi is higher than for teacher Zimkitha. This shows again that the level of qualification of the teachers does not always determine the level of teachers' practice or the learners' performance. Teacher Zimkitha has more years of teaching experience. This shows that sometimes years of experience count with regards to the use of effective retention strategies and learners' performance.

School B

Grade 11

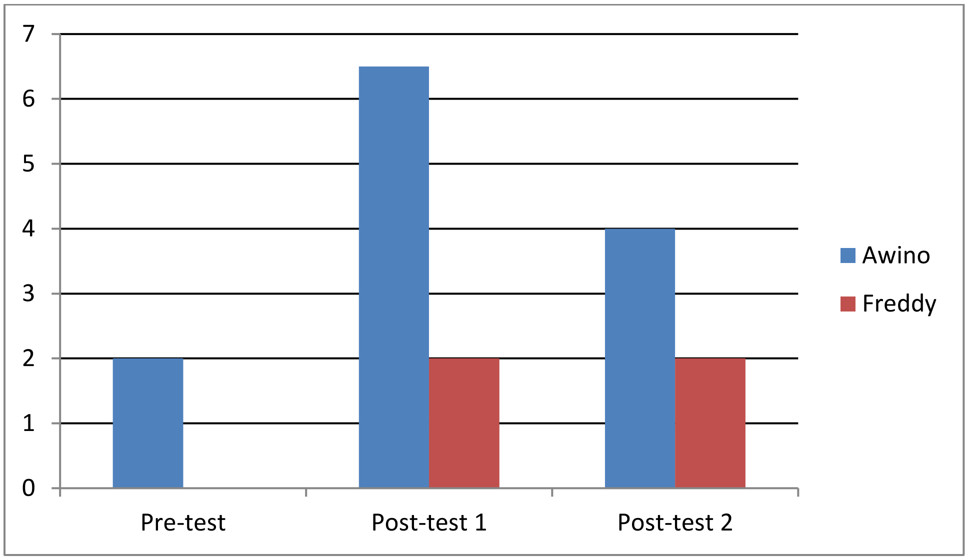


Figure 4.3 School B, Grade 11 test results

From the information illustrated in the graph, it is clear that there was poor retention during the pre-test when it comes to teacher Freddy's class. The pre-test class average for teacher Freddy's class was zero.

After teaching, however, there was constant retention. There is evidence of prior exposure to retention strategies when it comes to the learners from teacher Awino's class based on the results of the pre-test. The learners retained even more after teaching using retention strategies. The researcher was a participant observer with teacher Awino. Even though the graph shows that the learners' retention dropped as time went by, teacher Awino's class still outperformed teacher Freddy's class. Looking back to the profiles of these two teachers, teacher Awino is qualified to teach mathematics while teacher Freddy is not. Teacher Awino also has a lot more years of mathematics teaching experience compared to teacher Freddy.

Considering all these shown above, other classes above included, it is fair to conclude that the right qualification and the years of experience do count when it comes to the usage of effective teaching retention and revision strategies and the performance of the learners in mathematic or even other subjects. Learners are more likely to retain and perform better when the teacher is qualified to teach a particular subject and has more teaching experience.

Grade 12

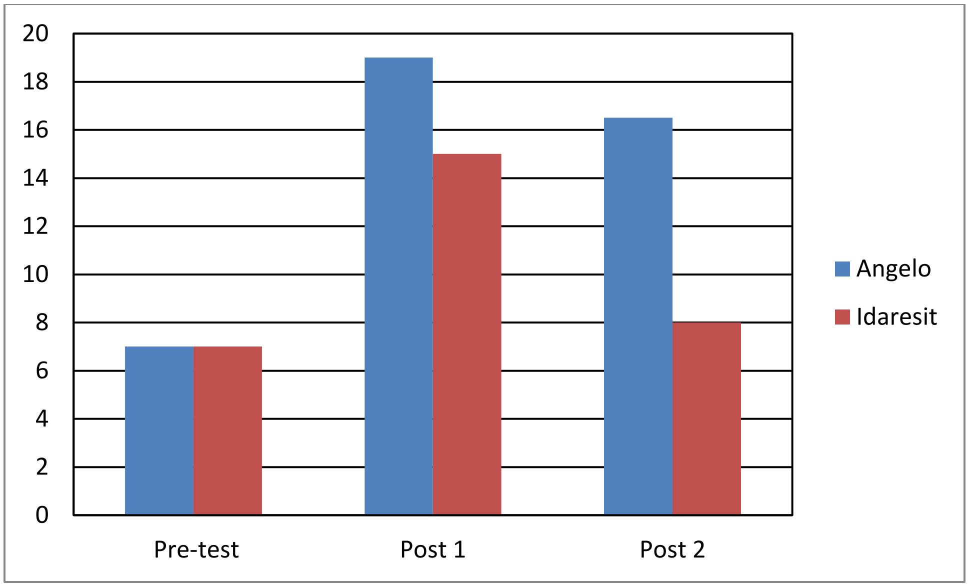


Figure 4.2 School B, Grade 12 test results

Looking at the graph above, it appears that learners' retention or their prior knowledge was the same for both classes. However, teacher Angelo's class demonstrated a higher level of retention compared to teacher Idaresit's class throughout the testing procedure.

The class averages for both classes dropped after the more delayed test, but there was not much change for teacher Angelo's class, especially compared to teacher Idaresit's class. Even though these two teachers have the same qualification, teacher Angelo had more years of mathematics teaching experience. Teacher Angelo has also worked in collaboration with the participant-observer after the pre-test. These show that the level of qualification and the number of years of experience count toward learners' retention and performance. Effective teaching retention and revision strategies enhance learners' performance. To conclude from the analysis of the results of the study, the level of qualification and number of years of teaching experience mostly count, but not all the time. The usage of effective retention and revision strategies always counts. Because all the graphs indicate that post-post-test (delayed post-test) scores dropped compared to the previous test (post-test) for all the classes represented; the researcher concludes that the time frame between the last teaching period and the test affects the test scores.

This finding is consistent with the idea of Rohler and Tylor (2006) who state that manipulating the 'RIs' (non-trivial interval) has an impact on retention and thus test performance with short gaps being more beneficial. However, the graphs for all the classes have also indicated that the 'RIs' had not affected all the learners in the same way, with the scores of the learners who seem to be exposed to less explicit retention strategies drastically dropping with time compared to others.

Overall, the teachers who used more explicit retention strategies demonstrated better test scores compared to the others. However, these test results are not to be generalised beyond the study's confines. The findings' generalisability was reduced by the procedure of purposive sampling. Thus, the conclusions are to be viewed as that of the two selected schools in Oshikoto region in Namibia only. Also, these pre- and post-test results may not be the best form of evaluation tool as many factors may have contributed to the learners' grades or performance. However, it is one of the most suitable ways to assess whether retention and revision strategies work or not.

In the following section, the researcher will present and discuss the data from the questionnaires for all 10 teachers.

4.4.3 Questionnaires by the 10 teachers (Appendix 8-10)

As described in chapter 3, questionnaires were the concluding stage of the data collection process. This chronological order was part of purposive sampling. The researcher used questionnaires to produce additional data for the study from all the participant teachers, in ways where she gets their angle or perspective. The questionnaires were limited to the teachers' views and experiences on the use of retention and revision strategies.

The main aim of this study was not necessarily to compare the teachers or the two schools but rather to get collective views, to share ideas with one another and to contribute to answering the main research question: How do Namibian senior secondary school mathematics teachers perceive and experience the facilitation of mathematics through retention and revision strategies? For all the two schools, there was nothing indicated on the questionnaires that could identify with the teachers' identities. The completion of the questionnaires by all teachers, along with those that made up the eight selected cases was therefore anonymous for both schools. The questionnaires were mainly used to see what the participant teachers had learned from the intervention and to share these ideas with the researcher. For this reason, the researcher purposively made the questionnaire the last phase of the data collection process after interviews and classroom observations.

The main objective of this study was to conduct research that might inform and contribute to how the Namibian senior secondary mathematics teachers perceive, use different retention strategies in their teaching and overcome possible challenges through sharing of ideas. Hence the data from the *unstructured* part of questionnaires were presented and discussed collectively. The findings would help supply the researcher with the necessary data as a starting point to build on the implications of the study.

The questionnaires mentioned above comprised of three questionnaires which contributed to the data collection for the study. They constituted one semi-structured questionnaire (multiple choice & unstructured) and two unstructured questionnaires. These questionnaires were completed by all 10 the teachers from the two schools including the four respective cases per school (8 teachers) (See Appendix 8). These questionnaires altogether were made up of a total number of 19 questions of which 4 were structured. These imply that 21% of the whole questionnaire method was structured and 79% was unstructured.

4.4.3.1 Structured questions

As indicated earlier in section 4.4, the findings were established on four main themes namely: retention strategies and revision strategies; challenges facing the teachers; ways of studying retention strategies of the teachers and ways learners' retention can be improved. The data gathered from the structured questions covered only the first aspect or theme of the study. Therefore, the discussions below point to the first of the four themes. The teachers' views were therefore collected under the first theme as indicated below:

4.4.3.1.1 Retention and revision strategies

The researcher established separate tally records for all items and created tally marks for every potential answer for each item. These items were identified from the theoretical framework as ideas to consider with regard to the four themes stated above. The researcher identified the most popular answer for every item as presented on the tally charts. The tally charts were then interpreted afterwards.

The tally tables below (4.14- 4.18) show a summary of how the ten teachers from the two senior secondary schools responded to the emerging themes above for each structured question or item, per teacher, per school. From the analysis of the *structured questions*, the teachers' responses were analysed and presented under the above-mentioned theme. Tables 4.14 and 4.15 represent the raw data for the teachers' answers for each school respectively. Table 4.16 summarises tables 4.14 and 4.15. Table 4.17 integrates the data for both schools and Table 4.18 is a discussion of the data for both schools.

Table 4.15: Tally representation of the teachers' answers for school A

A) **Retention strategies** 1. When you want your Grade 11 and 12 students to memorise facts in mathematics which of the following do you use?		
	Tally Marks	**Frequency**
A Diagrams e.g. Venn diagrams & KWL diagrams	|	1

B Mnemonics		0
C Lyrics and songs	|	1
D A & B	||||	4
E Other Reason:		0
	Total	**6**
B) Revision strategies 2. After showing your students a method or several ways of solving a particular problem you let your learners practice by:		
	Tally Marks	**Frequency**
A Collecting a lot of similar practice problems into one assignment	|	1
B Distributing a lot of similar exercise problems across two or more practice sessions	|	1
C Distributing a variety of exercise problems equally across over two or more practice sets	|	1
D Divide the past learned work through a variety of short exercise and activities	||	2
E Other Reason:	|	1
	Total	**6**
3. How often do you give your learners at least one mathematical challenging sum/practice problem (demanding thought) where learners are expected to be accountable to themselves and others for their answers through showing their workings?		
	Tally Marks	**Frequency**
A After a lesson	||||	4
B After a topic	|	1
C Once week		0
D Once a month	|	1
E Other Reason:		0
	Total	**6**
4. When you compile practice problems:		

	Tally Marks	Frequency
A You give the exact practice/exercise problems in the same order as that of the textbooks	||	2
B You give exercise problems based on a given lesson at a time	|||	3
C You include further questions of the previous lessons within practice set of the succeeding lesson	|	1
D You give practice problems after completion of a topic		0
E Other Reason:		0
	Total	**6**

Table 4.16: Tally representation of the teachers' answers for School B

A) Retention strategies 1. When you want your Grade 11 and 12 students to memorise facts in mathematics which of the following do you use?		
	Tally Marks	**Frequency**
A Diagrams e.g. Venn diagrams & KWL diagrams	|	1
B Mnemonics	|	1
C Lyrics and songs	|	1
D A & B	|	1
E Other Reason:		0
	Total	**4**
B) Revision strategies 2. After showing your students a method or several ways of solving a particular problem you let your learners practise by:		
	Tally Marks	**Frequency**
A Collecting a lot of similar practice problems into one assignment	|	1
B Distributing a lot of similar exercise problems across two or more practice sessions	||	2
C Distributing a variety of exercise problems equally		0

across over two or more practice sets		
D Divide the past learned work through a variety of short exercise and activities	|	1
E Other Reason:		0
	Total	**4**
3. How often do you give your learners at least one mathematical challenging sum/practice problem (demanding thought) where learners are expected to be accountable to themselves and others for their answers through showing their workings?		
	Tally Marks	**Frequency**
A After a lesson	||	2
B After a topic	||	2
C Once week		0
D Once a month		0
E Other Reason:		0
	Total	**4**
4. When you compile practice problems:		
	Tally Marks	**Frequency**
A You give the exact practice/exercise problems in the same order as that of the textbooks		0
B You give exercise problems based on a given lesson at a time	|||	3
C You include further questions of the previous lessons within the practice set of the succeeding lesson	|	1
D You give practice problems after completion of a topic		0

E Other Reason:		0
	Total	**4**

Summary:

School A and School B

The data of the two schools presented on the two tables above are summarised below on one table to compare the two schools. The table below intends to show the relationship between the two schools by analysing and interpreting the responses of the teachers per school based on the most suitable or appropriate response (Highlighted/Bold), as per the theoretical perspectives reviewed in Chapter 2. The tally marks illustrate the number of teachers who indicated the most suitable answers from the multiple-choice questions of questionnaire 2 (Appendix 9).

Table 4.17: Tally representation of the teachers' answers for both schools A and B

		SCHOOL A	SCHOOL B
QUESTIONS	ITEMS		
A.1.	A	|	|
	B		|
	C	|	|
	D	||||	|
	E		
B. 2.			
	A	|	|
	B	|	||
	C	|	
	D	||	|
	E	|	
3.	**A**	||||	||

	B	|	||
	C		
	D	|	
	E		
4.	A	||	
	B	|||	|||
	C	|	|
	D		
	E		

Based on the table above, the results show those teachers from school A showed more understanding regarding retention and revision strategies compared to school B. School A had more tallies for the most suitable answers than school B. As stated earlier, the aim of this study was, however not necessarily to compare the teachers nor the schools but rather to get a collective view on the Namibian teachers' understanding on retention and revision strategies and to contribute to answering the main research question:

How do Namibian senior secondary school mathematics teachers perceive and experience the facilitation of mathematics through retention and revision strategies? The next two tables present and analyse the results provided in the three tables above to represent the ten cases as a collective. The first table presents the data and the second table analyses the data.

Table 4.18: Teachers' answers for both schools

A) Retention strategies 1. When you want your Grade 11 and 12 students to memorise facts in mathematics which of the following do you use?		
	Tally Marks	**Frequency**
A Diagrams e.g. Venn diagrams & KWL diagrams	||	2
B Mnemonics	|	1
C Lyrics and songs	||	2
D A & B	~~||||~~	5

E Other Reason:		0
	Total	**10**
b)Revision strategies 2. After showing your students a method or several ways of solving a particular problem you let your learners practice by:		
	Tally Marks	**Frequency**
A Collecting a lot of similar practice problems into one assignment	||	2
B Distributing a lot of similar exercise problems across two or more practice sessions	|||	3
C Distributing a variety of exercise problems equally across over two or more practice sets	|	1
D Divide the past learned work through a variety of short exercise and activities	||||	4
E Other Reason:		0
	Total	**10**
3. How often do you give your learners at least one mathematical challenging sum/practice problem (demanding thought) where learners are expected to be accountable to themselves and others for their answers through showing their workings?		
	Tally Marks	**Frequency**
A After a lesson	~~||||~~ |	6
B After a topic	|||	3
C Once week		0
D Once a month	|	1
E Other Reason:		0
	Total	**10**
4.When you compile practice problems:		
	Tally Marks	**Frequency**
A You give the exact practice/exercise problems in	||	2

the same order as that of the textbooks		
B You give exercise problems based on a given lesson at a time	卌 |	6
C You include further questions of the previous lessons within the practice set of the succeeding lesson	|	1
D You give practice problems after completion of a topic	|	1
E Other Reason:		0
	Total	**10**

Table 4.19: Discussion of the teachers' responses to structured questions for both schools

Component	Items (questionnaire questions)	Most popular answers	Researcher's comments
A)Retention strategies	1. When you want your Grade 11 and 12 students to memorise facts in mathematics which of the following do you use? A) Diagrams e.g. Venn diagrams & KWL (Know Wonder Learn) diagrams B) Mnemonics C) Lyrics and songs D) A & B E) Other	D	This question was targeting to explore the teachers' experiences concerning mnemonics, drill-and-practice, advance organizers and rote learning. The best strategy for improving memory ability is mnemonics strategy (Bah et al., 2019: 93). The answer most popularly given to this question shows that more teachers could relate to some of the recommended retention/memorisation strategies for secondary school learners. Bah et al. (2019: 93) states that mnemonics assist both learners and students from secondary or tertiary education to keep immediate information in mind. D is, therefore, the most appropriate answer for this particular question. It therefore appears that more of the teachers could relate to the idea of identifying when to use which retention strategies. However, the researcher also got an impression that the teachers do not have sufficient knowledge about retention strategies. Because, as revealed by the two tables for every school, none of the teachers from both the schools could indicate other strategies outside the multiple choice provided as indicated in the two tables above. For example, advanced organizers are instructional approaches used to enhance learning and retention of new knowledge/learning material (Ames, Ackerson & Luiten, 1980). Drill-and-practice is also a

			recommended retention strategy for improving insight for dealing with non-problem and problem-based tasks (Kindt, 2011:137; Van De Wale et al., 2010:69). Also, during the interviews (the first data collection method), and interaction with the teachers, the teachers gave an impression that they did not have any idea about the terms retention and revision strategies. They did not have an idea about special terms used to describe recognised strategies that help learners deal with forgetting. The researcher also noticed during the interviews that the teachers did not know what mnemonics are. However, the teachers incorporated *some* of these strategies in their everyday teaching. They just didn't know the special terms. An interview allowed the researcher to get the participants to elaborate on their responses (Creswell, 2012: 218). Interviews therefore allowed the researcher to explore the teachers' experiences regarding retention and revision strategies very well. With interviews, the researcher has more control over the information received, can use probes to get rid of ambiguities. Interviews provide only information filtered through the interviewer's perspective as the researcher sums up the views of the participants (Creswell, 2012: 218). So, it was after the interviews, several interactions of classroom observations and possible research that might have been done by the teachers after interviews that the teachers were able to provide *some* of the answers. No teacher could provide any other answer outside the multiple choices. This reveals that teachers need to study more about retention and revision strategies.
B) Revision strategies	2. After showing your students a method or several ways of solving a particular problem you let your learners practice by A) Collecting a lot of similar practice problems into one assignment B) Distributing a lot of similar exercise problems across two or more practice sessions C) Distributing a variety of exercise problems equally across two or more practice sets D) Divide the past learned work through a variety of short exercise and activities E) Other	D	In this question the researcher intended to explore the teachers' experiences regarding massed practice, overlearning, distributed practice, exam-driven teaching and spiral revision. This category shows that most of the teachers seemed to have an idea that some revision strategies can be more effective compared to others. Even though the teachers might not know the strategies by their special terms/names *most* of the teachers seemed to find "distributed practice" and "spiral revision" more suitable and effective practices. Distributed practice and spiral revision are all ways of re-exposing learners to previous learned material covering various topics rather than a single topic. Interleaving or mixing problem ideas helps learners to think about which procedures to use which conceal understanding and learning more deeply rather than grouping similar problems at a time where a procedure becomes obvious to learners (Rohler & Tylor, 2006; Rohler & Tylor, 2007; Rohler, 2012). Research shows that learners remember better academically and performance is improved when provided with numerous opportunities to review past learned work, ("the spacing effect") (Julie, 2011; Rohrer & Taylor, 2006). Research has also shown that learners' chances of obtaining high scores on topics during tests and high-stakes examinations are increased when they revise previous work in a 'spiral' manner (Julie, 2011:2) Researchers argue that learners should rely more on 'distributed practices' or mass their learning into a single study session prior to examinations in case they do not need the knowledge afterwards (Rohrer & Taylor, 2007).

	3. How often do you give your learners at least one mathematical challenging sum/practice problem (demanding thought) where learners are expected to be accountable to themselves and others for their answers through showing their workings? A) After a lesson B) After a topic C) Once week D) Once a month E) Other	A (After a lesson)	For this question, the researcher mostly was trying to explore the teachers' experience regarding the DMTs. The result from this category shows that most teachers understand that it is good to give mathematics practice problems to learners at least for every lesson. This response concur with recent studies such as that of Julie (2011), that states that teachers should use at least ten to fifteen minutes for three to four periods a week to do sets of 'productive practice' exercises. The 'productive practice' incorporates the ideas of 'spiral revision' and 'deepening mathematical thinking'. 'Spiral revision' entails learners reviewing past learned work through short exercise sets. 'Deepening mathematical thinking' activities are instances where learners are presented with practice problems that provoke deep thinking and demanding that learners be able to justify their answers. No teacher could provide any other answer outside the multiple choices. This reveals that teachers need to study more about retention and revision strategies.
	4. When you compile practice problems: A) You give the exact practice/exercise problems in the same order as that of the textbooks B) You give exercise problems based on a given lesson at a time C) You include further questions of the previous lessons within practice sets of the succeeding lesson D) You give practice problems after a completion of a topic E) Other	B	This category was targeting the teachers' views on the shuffling method of practice problems and the distributed effect. The category indicates that 90% of the 10 teachers do not really give the much needed emphasis to the shuffling format. Even though most teachers seemed to agree earlier that the 'spacing effect' is the most appropriate strategy for effective practice, the teachers have depicted that they don't really apply it practically as they should. Repetition contributes to long-lasting retention. Repetition is similar to when you walk on a path many times, as you get more familiar. Some recent studies suggest some strategies, such as carrying practice problems over from previous topics in tests or practice sets of a new topic (Rohler & Tylor, 2007: 485). The researcher believes Learners will make sure they don't forget previously learned topics as they know previously learned content will pop up any time. No teacher could provide any other answer outside the multiple choices. This reveals that teachers need to study more about retention and revision strategies.

The data from the section above were presented and discussed collectively. As illustrated earlier, the questionnaires were the last phase of the data collection process. The completion of the questionnaires was done after the interviews, several interactions, classroom observations, and possible research that the teachers might have done. This was done so that the questionnaire content may not have any influence or cause any possible potential deception from the participant teachers who were interviewed and observed (see section 3.7.1.4, para.2). The main aim of this study was not only to explore the teachers' experiences but for the researcher and all the participants to share and learn from one another. In the process, the questionnaires were also developed to create opportunities for the participants and the researcher to learn from one another. The teachers' interactions with the researcher made them more aware of revision and retention strategies. The researcher also intended to learn something new from participants who may be more experienced.

Next follows a discussion of the *reasons* that the teachers gave for their multiple-choice answers on revision and retention strategies in 4.4.3.1 **(Appendix 9)**. The teachers' responses overlapped and were repeated by the teachers. Some teachers could not provide reasons for their answers. The teachers could not suggest strategies outside of the multiple choices provided by the researcher in the space provided. The teachers' responses to the respective questions appeared to have been much the same. Accordingly, the researcher clustered the answers that are more or less the same for the **ten** teachers and came up with generalised samples/extracts of teacher responses pointing to each aspect (retention and revision strategies) while pointing out the emerging themes with regards to the memorization and revision strategies, where she gets the perspective of the teachers' comments.

a) Teachers' reasons for retention strategies multiple choices (memorization strategies) (Appendix 9).

Retention or memorization strategies are strategies of instruction most suitable for covering cognitive procedures associated with 'retention' or recalling (Mayer, 2002:228-232).

These are strategies intended to promote recalling or *remembering*. The question asked in this category was: When you want your Grade 11 and 12 students to memorise facts in mathematics, which of the following do you use? Provide *reasons* (see table 4.18). The researcher categorised this question under retention strategies. Below are the teachers' responses.

Mnemonics:

- *Mnemonics help learners to grasp the content since it uses short keys. Mnemonics help with the recall of formulae needed to be used.*

Diagrams e.g. Venn diagrams & KWL diagrams (visual prompts)

- *Learners grasp content and remember easily from diagrams/pictures. Visual diagrams are the best as it is easier to have mental pictures to recall facts.*

Lyrics and songs (verbal prompts)

- *Learners learn more when things are expressed in fun or funny ways.*

The Three bullets above were the teachers' clustered responses (reasons or justifications) for question 1 (see Appendix 9). It seems like more of the teachers are in line with Hoque, (2019:2-4) who states that secondary school learners can memorise ideas in different ways and using various strategies such as visual and verbal prompts, mnemonics (visual and verbal prompts) (see tables 4.16 and 4.18). Secondary school learners are exposed to a lot of ideas that they are expected to remember. Bah et al. (2019: 93) argue that not only do mnemonics ease memory but also reduce stress and enhance memory intake, broadening memory scope for secondary learners. It appears that 20 % of the teachers (see table 4.14 & 4.18 question 1) consider using lyrics and songs in their grade 11 and 12 classrooms. However, several studies have regarded lyrics and songs as not common strategies for senior secondary but rather for pre- and primary school mathematics (Bah et al., 2019: 93; Hoque, 2019:2-4; DeLashmutt, 2007). Dzanic and Pejic (2016:40) consider songs and lyrics as a means for improving *young learners*' English language vocabulary and for influencing *young learners*' motivation for learning English.

b) Teachers' reasons for revision strategies multiple choices (Appendix 9).

These are instruction strategies most appropriate for covering cognitive processes associated with '*transfer*' (Mayer, 2002: 228-232). In other words, these are strategies that most enable assessment tasks and activities that deal with cognitive procedures intended to promote or improve the application of knowledge to new and unfamiliar situations. The specifics are discussed below. The questions asked under this category were: After showing your students a method or several ways of solving a particular problem you let your learners practice by? How often do you give your learners at least one mathematical challenging sum/practice problem (demanding thought) where learners are expected to be accountable to themselves and others for their answers through showing their workings? When you compile practice problems, which of these are you most likely to do? As in the previous section, the researcher clustered the responses of the reasons the ten teachers gave for their multiple choices in Appendix 9 (also indicated in tables 4.14-4.18). Below, the researcher groups the teachers' comments and discusses them while referring to the revision strategies the teachers pointed to, where she gets the teachers' perspectives. Tables 4.16 and 4.18 verified the analysis made by the researcher below.

Massed practice:

- *Collecting similar practice problems in one assignment allows repetition, allowing learners to be more familiar with the same thing. The strategy helps learners not to forget and it exposes learners to different questions on the same thing.*

- *When you compile practice problems there is no harm in using the exact practice/exercise problems as prescribed in the textbook should the textbook at least have 90% of the content needed to be covered in the syllabi. And it is a resource readily available to learners.*

These were the reasons given for the choices of question 2. A. Questionnaire 2 (Appendix 9). The results show that 20% of the ten teachers pointed to massed practice as their most preferred practice or revision strategy (see table 4.16 and 4.18 question 2.). 'Massed practice' requires that practice problems are collected from the same topic into one practice session. There is no contrast in the questions; learners repeat or do five or ten problems in one session. Massed practice is ordinarily interpreted as a procedure that takes place without rest between trials (Burdick, 1977, as cited in Steve et al., 2003:19). The continual task involving massed practice can have harmful effects on performance because of fatigue, and its effect on learning is minimal during transfer testing on retention (Schmidt, 1991; Stelmach, 1969, as cited in Steve et al., 2003:19). Research indicates that massed practice affects performance particularly and not learning (Steve et al., 2003:21). It is not a highly effective strategy for meaningful learning (see 2.3.2.1).

Overlearning:

- *When learners are given exercise problems based on a given lesson at a time, the lesson is handy. It is easy to use in a short time.*
- *Tests cover the whole topic and homework is for daily coverage.*

These reasons or justifications were given by the teachers who chose B for question 2 and 4. (see Appendix 9). The study results show 30 % of the teachers for question 2 and 60% for question 4 respectively gave the impression that they preferred overlearning (see table 4.16 and 4.18 questions 2 and 4.). Overlearning is when practice problems are spread across two or more sessions but still problems are similar (Rohrer & Taylor, 2006). In other words, all various sessions cover similar problems collected from one topic. The effects of overlearning on long-term retention are questionable (Rohrer & Taylor, 2006). The practice of the same learning material is a wasteful use of time (Rohler & Pashler, 2007:1) Just like massed practice, overlearning is not highly recommended, based on the literature (see 2.3.2.1).

Distributed practice & exam-driven teaching:

- *Including questions from previously learned topics in practice problem sets help in a way to make sure that learners are practising other lesson contents and not only the ones that they are busy with.*

- *Mathematics as a subject is a chain of topics (interdependent) and learners need to be encouraged not to learn topics in isolation.*

Both 'exam-driven teaching' and distributed practice entails learners covering a variety of topics while practising. 'Examination-driven teaching' (EDT) implies teaching learners the content of past examinations and questions hoped to come up in the upcoming examinations (Julie, 2013b:3). According to Julie (2013b:3b), 'EDT' has some advantages and disadvantages (see 2.3.2.3). The results of the study show that only 10 % (one teacher out of ten teachers) indicated for distributed practice (see table 4.16 & 4.18 question 2. C). 'Distributed practice' also known as 'spaced practice' implies distributing practice problems from different topics across two or more practice sessions (Rohrer & Taylor, 2006). Distributed practice is usually referred to as 'alternative skill learning' or 'practice infused with rest' (Burdick, 1977, as cited in Steve et al., 2003:19). Several studies have reported that distributed practice is the most productive strategy to maximize not only performance but learning too (Steve et al., 2003:20). Several researchers recommend that teachers should rely more on the spacing or distributed practice especially when the gaps between the latest learning sessions and the tests are delayed (Rohrer & Taylor, 2006). Distributed practice is one of the revision practices highly recommended for meaningful learning (see 2.3.2.4).

Spiral revision:

- *Dividing past learned work into a variety of short exercises and activities boosts the learners' confidence to exercise more as they realize that they actually can get some answers.*
- *Dividing past learned work into a variety of short exercises and activities also encourages the learners to work out more practice problems as they are not overloaded with work at a time.*

The results above show that 30 % of the teachers believe that revising past learned work through a variety of short exercises (spiral revision) enhances learners' motivation to learn mathematics (see table 4.16 & 4.18 question 2. D). Research has proven that revising work that has been dealt with in a *spiral* way enhances learners' mathematics tests and examination achievement scores (Julie, 2011:4). 'Spiral revision' has overlaps with distributed practice and due to its distributed or spaced effect it is therefore also one of the highly recommended revision strategies for insightful learning.

Deepening Mathematical Thinking:

- *Giving challenging activities after a lesson creates curiosity, interest, and promotes competition among the learners.*
- *I prefer giving challenging practice problems after a lesson so that the learners can incorporate the lesson content to solve the problem.*

The results from this study as indicated above seem to show that most teachers understand that it is good to give learners a mathematically challenging practice problem at least for every lesson. This means that sixty percent (60 %) of the teachers appear to acknowledge that learners need to be provided with opportunities where they can engage with mathematics problems (see Appendix 9 & tables 4.14-4.18 question 3). These opinions point to ‘deepening mathematical thinking’ (Julie, 2011:4). ‘DMTs’ require that learners justify their solutions. Justification is a way of showing understanding, which informs meaningful learning.

The tables (Tables 4.14-4.18) and the information above reveal that teachers can relate to retention and revision strategies even though they might not know the special names of the particular strategies. The results show that teachers have the potential to teach mathematics through retention and revision strategies, should they be provided with the necessary opportunities. They have the fundamental skills and this is positive. The literature in this study showed teaching through retention strategies is one of the fundamental approaches to teaching mathematics meaningfully.

4.4.3.2 Unstructured questions

Questionnaire 1: (See Appendix 8)

1. What do you understand about retention and revision strategies?

2. Are they the same or separate?

3. Provide examples of retention and revision strategies.

4. Do you think the use of different retention and revision strategies needs to be encouraged in teaching school mathematics in Namibia? Explain, giving examples.

5. There are a lot of recommended teaching and learning strategies to deal with learners’ forgetting in mathematics. Describe the strategies you use, to deal with your learners’ forgetting and give reasons why you use the specific ones?

6. How do you make extra time to use the different retention and revision strategies you mentioned in the above question and/or incorporate them within your working hours?

7. How do you make sure that a class of learners with different learning styles practice in revision groups in an effective manner? Give a practical example.

8. How do you encourage your learners to practice in your absence/without supervision? How do you make sure that they do practice?

9. Practice is very important in mathematics. How do you motivate your learners to develop a culture/habit of practising on their own (without being asked to do so)? Prompt: How do you select and design practice questions? What do you consider when giving learners 'practice'? Where do you get these practice or revision exercises?

10. What are the challenges that Namibian teachers face in the process of addressing the "forget problem" of their senior secondary school learners in mathematics?

11. How do you think the challenges you have stated in question 10 could be addressed?

Questionnaire 2: (See Appendix 9)

1. What do you know about effective teaching retention and revision strategies that can improve learners' retention in senior secondary school mathematics classrooms?

2. What are and why teach retention strategies in senior secondary school mathematics?

3. Are there differences between different retention and revision strategies or are they the same?

4. What is the relationship between revision and/or retention strategies?

5. What are the ways of studying retention/revision strategies of the teachers?

6. Where do you get challenging practice problems that you give to your learners?

7. On what basis do you choose the mathematically challenging problem?

Questionnaire 3: (see Appendix 10)

Please explain how you would introduce and teach any Grade 11 or 12 mathematics topic of your choice. Illustrate how you would use different retention and revision strategies to the best of your ability to help learners retain the content (for the content to last longer in their memories).

This questionnaire was just meant for the researcher to learn from the fellow teachers, but mostly for the researcher to gain deep insight into the level of implementation of retention strategies by the teachers.

The researcher analysed and discussed the teachers' comments from the three questionnaires pointing to the four aspects: retention strategies and revision strategies, challenges facing the teachers, ways of studying retention strategies of the teachers, and ways learners' retention can be improved.

The discussion hereafter is based on the teachers' opinions regarding the four aspects of the study as indicated above, which were identified based on the reviewed literature as the components that may help produce long-lasting retention. At some point, more than one question from the questionnaires pointed to a single aspect. The researcher also discovered that some comments overlapped and were repeated by the respondents. The teachers' responses to the respective questions seemed to have been much the same. Some teachers or most of them for certain questions, could not provide answers as they had the right to leave out particular questions as part of ethical procedures. Therefore, accordingly, the researcher clustered the answers that appeared alike and came up with generalised samples/extracts of teacher responses that focused on the same aspect. As illustrated earlier, the motive behind this study is not to compare the teachers nor the two schools but rather to provide a collective view or picture of the Namibian teachers' awareness, perspectives, understanding, and appreciation of retention and revision strategies as well as to contribute to answering the main research question: how do Namibian senior secondary school mathematics teachers perceive and experience the facilitation of mathematics through retention and revision strategies? Hence, the data from the *unstructured* part of the questionnaires were presented and analysed collectively. The extracts were extracted from the ten teachers' questionnaires and were listed in the form of bullet points as shown hereafter.

4.4.3.2.1 Retention and revision strategies

The responses clustered in this section (1) focused on the four sub-questions of the study. These were the ideas of what retention is, what retention and revision strategies are; what the differences are; the relationships and interrelationships among the main two strategies; why teaching retention strategies in senior secondary school mathematics is necessary; general practices/daily routines or procedures as a support system for retention and revision strategies; as well as why rote learning takes place.

a) Teachers' views on the concept of retention.

- *Retention is storing information for a lasting memory in such a way that it can easily be recalled.*
- *Retention means to keep something (learned content) for future use.*
- *Retention is the capacity to remember.*

The above are clustered responses from the ten teachers. The above comments seem to give the impression that after several interactions with the researcher, interviews, and classroom observations, the researcher could extract some good definitions from some of the teachers. Teachers seem to have a good understanding of what retention means. The extracts seem to acknowledge that retention is the capacity to 'remember' something at a later stage (Mayer, 2002:226). Retention refers to the continuous keeping of learned information to the memory in a way that it is effortlessly remembered in the future.

b) Teachers' views on the concept of 'retention strategies'.

- *Retention strategies are methods that are used by teachers to help learners understand and remember things that they have been taught well, and fast.*

The above response is what the researcher was able to extract from the few responses from only some of the teachers who could provide responses to this aspect or theme. The teachers seem to indicate that retention strategies are the techniques that the teachers use to enhance the learners' capacity to 'remember' something at a later stage, based on what retention is (Mayer, 2002:226). Retention strategies are methods used by teachers to help learners stick learned information to their memory and be able to retrieve it at a later stage.

c) Teachers' comments on differences/similarities between revision and retention strategies.

- *Retention strategies refer to activities or methods intended to help learners to recall information like formulas or steps in solving a problem.*
- *Retention strategies are strategies that you use during the presentation of the lesson and you inform your learners that for you to remember this, you have to use these particular strategies.*
- *Retention helps learners remember the steps or methods of the content.*
- *Retention strategies favour slow learners to help them cope with the learning pace.*
- *Revision strategies refer to the ways you go through topics a second time or more.*
- *Revision strategies are strategies that are used to repeat or emphasise over and over on a specific task or topic.*
- *Revision strategies are strategies that you use to revisit what you have already taught the learners.*
- *Revision is re-teaching topics already covered in order to refresh the learners' memory or establish knowledge or skills or prepare learners to take exams.*
- *Revision helps learners practise and rehearse retention methods in solving mathematics problems.*

- *Revision strategies favour learners in answering examination and test questions.*

From the bullets above, the teachers seem to confirm that ‘retention strategies’ are strategies that enforce remembering. Such a view is consistent with Mayer (2002:232) who indicates that retention strategies are methods (such as strategies of instruction and assessment) that involve the cognitive demands associated with and promote ‘remember’. Based on the last bullet above on retention strategies, the teachers also confirm that retention strategies (e.g. mnemonic guidelines) provide stimulation and help with long-term memory of the mathematics key concepts for learners who may experience challenges with retaining information and connection to their world (DeLashmutt, 2007). Retention strategies make the recalling process easier because retention strategies, for example mnemonics, capture information in a way that is easy to remember. Apart from easing memory, mnemonics are very helpful in remembering a lot of complicated ideas, improve memory intake, reducing stress and helping expand the memory capacity (Bah et al., 2019: 93).

The bullets above also seem to indicate that the teachers have an idea that revision strategies are about revisiting what has already been covered or taught. However, the extracts above also show that the teachers could not point out the most important objective for revision strategies which is not repeating work but promoting ‘transfer’ of knowledge to new mathematical ideas or problems (Mayer, 2002). These are strategies most appropriate for including cognitive demands associated with ‘transfer’ or application of knowledge (Mayer, 2002: 228-232).

Revision strategies are the strategies that most enable instruction and assessment activities and tasks that deal with cognitive demands for promoting the ability to transfer learning to new situations. The last two bullets on revision strategies seem to indicate that teachers are aware that revision strategies are about practising (repeating, to improve) as well as that revision strategies thus help enhance learners’ tests and examination scores (Julie, 2011:4). Some of the revision strategies have a ‘distributed effect’ (Rohrer & Taylor, 2006; Burdick, 1977, as cited in Steve et al., 2003:19; Julie, 2013b:3; Julie, 2011:4) which means covering more than one idea or topic per practice session (e.g. distributed practice, exam-driven-teaching, and spiral revision). Also, the nature of activities and tasks for some revision strategies (e.g. exam-driven teaching, spiral revision and deepening mathematical thinking) is such that it is similar to the questions asked in national examinations (Julie, 2011:4). For these two reasons, the researcher declares that revision strategies aid with improving tests and examination achievement scores.

d) Teachers’ comments on the relationship between retention and revision strategies

- *Retention and revision strategies can be the same or separate; there are common grounds.*
- *They are separate but serve the same purpose.*

- *The relationship is that these all help learners to remember the methods, steps, or formulae required for them to pass mathematics.*
- *Retention strategies make revision easy whilst revision strategies help retention strategies to be mastered.*
- *They are interlinked. You repeat to retain the information better, and even better with understanding.*

From the first four bullets of the teachers' extracts above, teachers appear to have become aware from the intervention that revision and retention strategies are interdependent and ought to work together for a common goal which is the retention of school mathematics. In a way, it appears that the teachers believe that retention and revision strategies are the ways to address the problem of forgetting. Retention and revision strategies can be identified as two separate methods, but are interdependent. While all have their distinctive and unique features, within the context of retention, they cannot be perceived or play in isolation. A successful reciprocation is crucial for meaningful or insightful learning, a way to deal with forgetting (Mayer, 2002:226). Both retention and revision strategies have one common goal, to help learners retain and remember what they have been taught.

From the last bullets, it seems that some of the teachers also noted that integration of retention and revision strategies brings about 'meaningful learning' or learning with understanding (Mayer, 2002:226).

e) Teachers' examples of retention and revision strategies

Retention

- *Using words or statements that can easily be remembered such as CAST SOH CAH TOA and TRER (Transformation; Reflection, Enlargement & Rotation) in 'Transformations'*
- *Diagrams*
- *Linking existing knowledge to new knowledge*
- *Formulas*
- *Songs*

It appears that the teachers have peculiar retention strategies that they use. The first bullet points out the ideas of mnemonics whereby teachers use guidelines or strategies that provide visual or verbal prompts/stimulation for learners to help them connect to their world and with long-term memory of the key mathematics concepts for them to retain or recall information (DeLashmutt, 2007). A mnemonic such as 'CAST' (Cosine, All, Sine & Tan) is an example of an acronym used for aiding learners to remember the signs of the trigonometric functions in the quadrants (Quadrant Rule) for helping learners solve trigonometric equations in a particular range.

An acrostic-like acronym mnemonic such as 'SOHCAHTOA' can be a visual or verbal prompt, used to help learners remember how to represent or express trigonometric ratios. Diagrams can also be used as visual prompts. In the context of retention strategies, diagrams can be actual models and images used especially with learners who memorise better with charts, pictures, graphs, or similar devices (see 2.3.1.1). The teachers' comments also seem to suggest the idea of 'advance organizers' by David Ausubel, one of the ways used for helping learners connect existing knowledge to new ideas (Kirkman & Shaw, 1997:3). David Ausubel's view was that learners 'must' link new ideas and suggestions (new material) to their already existing knowledge, to learn meaningfully (Novak, 2002: 549). Formulas capture key ideas of mathematics in a manner more or less similar to mnemonics and thus form part of retention (memorization) strategies and assist with retention. The teachers' extracts above show that some teachers consider songs as some of the retention strategies for senior secondary mathematics.

However, none of the teachers could provide an example of a song or at least details on which topic. Several studies have also shown that lyrics and songs are not suitable strategies for senior secondary school mathematics but rather for pre- and primary school mathematics and mostly for helping young learners improve their vocabulary and arouse their motivation for learning English (Bah et al., 2019: 93; Hoque, 2019:2-4; DeLashmutt, 2007; Dzanic & Pejic 2016:40).

Revision

- *Repetition*
- *Repetition/re-teaching and giving more practical activities*
- *Doing various practice problems*
- *Asking the right questions*
- *Testing oneself frequently with homework, activities, and tests*
- *A lot of practice problems on the same topic*
- *Interleaving different topics*
- *Past question papers*
- *Opportunities for learners to think while they work*

Just like with the retention strategies suggestions from the teachers' extracts, some of the comments cited by the teachers seem to point at the revision strategies from the literature reviewed by the researcher even though the teachers could not point out the particular strategies. The first five ideas can be executed through any of the revision strategies such as massed practice, overlearning, distributed practice, exam-driven teaching, spiral revision, or deepening mathematical thinking (see 2.3.2). The revision strategy can be identified based on the nature of conditions, gaps, and consistency (Pashler & Rohrer, 2007).

Therefore, the first five bullets point to any of the revision strategies depending on the consistency or gap (the theoretical and the implementation aspects) in which the teachers choose to carry them out. A lot of similar practice problems assure massed practice. Interleaving different topics can be done through exam-driven teaching, distributed practice, spiral revision, or deepening mathematical thinking (see 2.3.2). Teaching work of past examination indicates examination driven teaching (Julie, 2013b:3). The instances where learners are provided with opportunities to think deeply and justify their reasons while solving problems point out to deepening mathematical thinking (Julie, 2011).

f) Teachers' reasons for retention strategies (memorization and revision strategies)

Teachers provided a variety of reasons for using retention strategies:

- *To prevent failure due to forgetting and uncertainty caused by a lack of familiarity with the content. To improve results. In Namibia, mathematics is the most failed subject at the secondary school level.*
- *The main aim is to help learners easily learn, master, and remember what they have been taught.*
- *To increase performance in mathematics.*
- *Learners also perform better when they are given more work to practise/revise. They train how to answer questions on different topics which helps them remember methods in tests and examinations.*
- *To grasp the content better.*
- *To reduce the time learners take to grasp topics.*
- *Mathematics is a practical subject; learners master the content better when they are shown methods that they can remember through visualizing or writing them down.*
- *To promote motivation and positive disposition in school mathematics learning and teaching.*

From the first four points of the teachers' extracts, the teachers seem to confirm that forgetting is one of the major causes of poor performance and low achievement in mathematics (Julie, 2011); and that because people forget a lot of what they learn, learners could benefit from strategies that produce long-lasting retention (Rohrer & Pashler, 2007; Julie, 2011). From the second point above, the teachers also appear to indicate that the motive behind teaching retention strategies is to prevent rote learning and promote meaningful learning (to learn with understanding or to master). According to Mayer (1999), cited in Mayer (2002), rote learning is based on learning viewed as the reception of knowledge where learners seek to pile up new information into their memory with no understanding.

‘Meaningful learning’ is based on the constructivist view of learning as knowledge construction where learners seek deep understanding, to be able to apply what they learn to new and unfamiliar situations (Mayer, 2002). Bullets three and four are also consistent with the idea of Julie (2011:4) that when learners revise through spiral revision and deepening mathematical thinking, their chances for obtaining high achievement scores in tests and examinations are enhanced. According to the bullets five, six and seven, the teachers seem to concur with the idea that, besides easing memory, some retention strategies are very helpful in recalling a lot of difficult ideas, improve memory intake, reduce stress and help increase the memory capacity (Bah et al., 2019: 93).

Also, some strategies such as mnemonics use short keys and this helps learners grasp concepts better. From the last point, the teachers appear to point to ‘deepening mathematical thinking’. Both motivation and dispositions are related to the ‘disposition of productive struggle’ proposed in Julie (2011:4) and Julie (2013a) (see 2.3.2.5).

Looking at the depicted teachers’ responses in part (a), the researcher noted that 90 % of the teachers were unable to define the concepts retention/revision strategies even though it appeared that they could relate to a substantial amount of strategies and knew the examples of each. The researcher believes that features entailed by a definition of a certain concept are necessary for deep insight about an idea; thus, teachers could be encouraged to learn more about retention and revision strategies for a successful implementation. However, some responses from the teachers show that participant teachers have some intuitive retention and revision strategies.

g) Teachers’ teaching practices (routine, usual procedure) and discourses that support retention and revision strategies.

In this section, the discussion and analysis of the ten teachers’ comments from the open-ended questions are done based on the mathematical teaching practices and discourse desired by meaningful learning through retention and revision strategies as discussed earlier in this chapter.

The researcher identified the components deriving from the ideas of meaningful learning, learner-centred education, problem-solving, and deepening mathematical thinking from the theoretical framework reviewed in Chapter 2. These components are the five action words (probing understanding, sense-making, drive learning, exploratory/inquisitive discussions, and learner interaction) that are found to most likely occur with or lead retention and revision strategies towards promoting deep understanding or meaningful learning (see 4.4.2.1).

The researcher used the data from the support classroom visits to analyse the teachers’ ideas regarding the identified codes earlier in this chapter but the researcher still wanted to get and include contributions from the teachers who were not observed by using the data from the questionnaires.

As indicated earlier, for the questionnaire's unstructured questions, the researcher gathered and clustered the ten teachers' comments that pointed to the same aspect. This was done because the researcher discovered that some of the ideas in the responses to the unstructured questions were repeated and overlapped. The teachers appeared to have similar opinions to some questions. Some teachers also seemed to provide answers at wrong places though relevant ideas. Below, therefore, the researcher collected the points or suggestions for all ten the teachers that focused on the same idea as illustrated below.

i. Probing understanding

Probing understanding means that the teachers request learners to justify their answers as well as the methods they have used to come to the answers to investigate or probe understanding. When learners learn with understanding, their recalling strategies are enhanced and they are enabled to link new and unfamiliar mathematical ideas to their existing knowledge (Artzt et al., 2008:9). The teachers' suggestions that the researcher found being in line with the idea of probing understanding are listed below as teachers' extract responses.

- *Giving at least two practical activities per topic but with questions asked in different ways to stimulate learners' critical thinking.*
- *Showing methods to answer problems step by step and giving homework to check whether learners understand.*
- *Encourage learners to find ways of their own to always work on problems; this way they will not forget.*
- *Ask learners to formulate their own questions related to the topic so that they test how well they understand the topic.*
- *Promote reading with understanding.*
- *Promote learning formulae with understanding.*
- *When learners use their language/English skills to read with understanding it helps them to remember what they have been taught.*

The points above seem to give the impression that the teachers are aware that learning with understanding is crucial in a mathematics classroom. Julie (2011:4) refers to the concept of 'deepening mathematical thinking', the instances where learners' chances to engage with mathematics are enhanced by providing them with teaching environments, learning and challenging mathematical problems that reinforce deep understanding, the capacity to elaborate and motivate solutions and to reflect on their working. The suggestions above seem to be in line with Julie's idea. The researcher believes that asking learners the questions of why, how, when, where, and what during classroom instruction is one suggestible idea in this regard. These types of questions create opportunities for learners to justify their solutions and investigate understanding.

ii. Sense-making

Sense-making implies that teachers refer explicitly to mathematical conventions (formality), symbolism (analogies), definitions, axioms, and theorems (principles). The points extracted from the teachers that pointed to this aspect are listed below.

- *First of all, it's important to tell learners that mathematics is a universal language.*
- *Writing down all the steps for methods when it is necessary.*

The suggestions above point to helping learners know and understand mathematics rules and principles of doing things and dealing with mathematical problems. The researcher is however of the opinion that the suggestions above shouldn't be the only ideas but any other intentions for establishing sense-making in the classroom, such as asking learners to compare ideas and then comment and then asking questions to explore or investigate whether learners are making sense of the ideas should be incorporated. Examples are asking learners to compare real-life receipts from the shop, using rate to determine the best value of money or compare simple and compound interest which establish effort or intentions for learners' sense-making . The teacher can explore the learners' answers by asking them why they opted for which option. Exploring learners' answers leads to valuable discussions and enhances both teachers' and learners' awareness of possible misconceptions and misinterpretations of ideas (Cockcroft, 1982:72).

iii. Drive learning

Drive learning refers to teachers using learners' prior knowledge to start classroom discussions. Teachers ensure that learners' opinions or contributions are valued, inform, and guide the instruction process. These opportunities increase the likelihood that our learners will be able to remember and use new ideas that they are taught by assisting them to link the new ideas to their existing knowledge. Below are the teachers' opinions for establishing drive learning.

- *Help learners towards linking existing knowledge to new knowledge (drive learning)*
- *When learners can link mathematics to real-life situations they recall better.*
- *using a real-life example or examples related to real-life during teaching*
- *applying real-life situations*
- *Using practical methods e.g. for money and finance I bring real-life receipts and statements.*
- *When the teacher uses funny and good examples when teaching, learners will always relate to them to remember the things they were taught.*
- *Using usual/familiar images that they can remember and relate to.*
- *I ask learners about their strategies that can help them remember.*

The ideas above seem to indicate that the teachers recognise the fact that they should relate what they teach the learners to what the learners already know (e.g. the first seven points). The last point seems to show that teachers are implying that the learners' contributions in the classroom should be used to drive the teaching and learning process. These are the learners' resources. Schooenfeld (1985:12) points out and refers to the notion of 'resources' consisting of relevant sets of ideas necessary for problem-solving, algorithmic procedures, routine procedures, and procedural knowledge feasible or available to a learner as an individual.

iv. Inquisitive exploratory discussions

Inquisitive exploratory discussions mean that teachers encourage discussions between learners, those not interfered with by the teacher included. According to Lash and Doerr (2003:212) knowledge should be built by active learners and not received by passive learners. This idea of Lash and Doerr is in line with the constructivist and democratic principles on which learner-centred education is established.

- *Each learner should be given a chance to express their views on different mathematical problems being revised.*
- *I always encourage learners to work at their own pace.*
- *Doing corrections to activities together.*
- *Giving learners more problems to practice on their own and discuss feedback with the whole class.*
- *Group the learners according to mixed abilities.*
- *It is good to vary methods to suit different learning styles, e.g. use diagrams, explain in words, and also give lots of practice and group discussions.*
- *As a teacher, make sure the work given to the learners is clear for them to have the courage to attempt the work given to them on their own.*
- *I have a phrase; 'you must solve a Maths problem every day'.*
- *Ask learners to present their homework/tasks in class in their groups.*

From all the bullets above the teachers give the impression that certain things need to be done in the class for learners' discussions, including not only those between teachers and learners but those done between the learners only. Teachers seem to be highlighting that a teacher should be a facilitator rather than a transmitter of knowledge. According to Walshaw and Anthony (2008:522), these opportunities help learners to make sense of their own learning experiences through listening to other learners' explanations rather than imitating procedures.

v. Learner interaction

Learner interaction implies allowing learners to comment on and positively criticise other learners' ideas. These opportunities allow learners to engage with the curriculum, exchange viewpoints, and take charge of their learning (Malan, 2000:26; Yakel & Cobb, cited in Walshaw & Anthony, 2009:523).

- *Structured peer-assisted learning*
- *Structured peer-assisted learning activities*
- *Put learners in groups of mixed abilities and apply peer tutoring.*
- *Use the above-average learners on a particular content to teach the average and below-average learners in groups.*
- *I also encourage peer teaching as sometimes learners understand better.*
- *Pairs/group work*
- *Always guide learners to be able to pick up keywords in mathematical language/terms for them to be able to relate them to the methods and formulae needed to be used to solve the given problem.*

All the first six opinions above seem to be pointing to the ideas of group work and peer tutoring. Peer tutoring will demand that the learner-teachers polish up their skills before teaching anything to others, this will require that they review and learn something more than once which will aid binding the subject matter unto their brain (Hoque, 2019: 6). When learners explain the work to others, memories that were rusting off are reactivated, strengthened, and consolidated. Peer teaching not only increases retention but also promotes active learning (Sekeres et al., 2016). The last point seems to be consistent with the idea of Driver and Oldham (1986:112) that the teachers' role is supposed to be guiding this interaction in a way that will lead learners to their mathematical discovery and understanding.

h) General procedures that support retention and revision strategies.

From the unstructured part of the questionnaires, the researcher still wanted to extract ideas from the teachers about 'general strategies' or other forms of effort that the teachers can engage to boost the effectiveness of retention and revision strategies. Still, the researcher clustered the teachers' ideas and categorised them based on some codes as indicated below:

i) Teachers' opinions on general strategies:

- *Apply learner-centred education strategy.*
- *Use models and teaching aids often*
- *Teach learners to over-learn new information.*

The teachers' ideas above appear to be relevant parts of the support system for retention and revision strategies. The teachers' first point seems to suggest that learner-centred education is a crucial aspect in support of retention and revision strategies. The teachers seem to agree that when the instruction focus shifts from the teachers to the learners, learners take charge of their learning and are led to their discoveries and understanding (Serin, 2018:164; Malan, 2000:26) which contributes to retention. The second point is focused on the use of models and teaching aids which form part of learner-centred education. The last point seems to suggest that the more the subject matter is repeated, the more the consolidation (Hoque, 2019: 2).

ii) Teachers' opinions on general time management:

- *Give relevant problems that are well planned as it might be difficult during working hours to assess your strategies due to the number of learners in a class group.*
- *Incorporate retention and revision strategies within the working hours; no extra time is required in most cases, or through extra classes in the afternoons or weekends when possible.*

The teachers' ideas above appear to be in line with Julie (2011:4) who suggest that teachers should use 10 to 15 minutes for 3 to 4 weekly periods for 'productive practice'. The suggestions above also seem to support the idea that practice can be done during the lesson instead of giving practice to learners as homework, which helps in dealing with the problem of learners not doing homework (Julie, 2011:4; Julie, 2013b: 7-12; Okitowamba, 2018:2).

iii) Teachers' opinions on the accommodation of different learning styles:

- *Allow learners to use their strategies to arrive at solutions.*

- *Individual learners should be given opportunities to express opinions on mathematical problems.*
- *Use various methods to cater for different learning styles, e.g. explain in words, and use diagrams.*

The first two points of the teachers' comments seem to agree with the idea of providing learners with opportunities to justify their solutions (Julie, 2011:4). As a result, these opportunities accommodate learners' ways of arriving at answers. The last point appears to suggest that when possible the teacher should use both verbal and visual prompts (mnemonics) as some learners memorise well verbally and some visually (Bah et al., 2019: 94).

_iv)_ Teachers' opinions on developing a culture of practice without close supervision:

- *Giving learners a challenging but brief task so that learners do not feel bored or overloaded.*
- *Don't limit the work that they need to practice on.*
- *Leave problems for learners to practice individually, mark, and give feedback. Double the work for learners who did not attempt anything.*
- *Tell them that mathematics is like sports and if they don't practise they will forget. Also explain that homework is not necessarily always about marks.*
- *Motivate learners; increase learners' appetite for the subject by sharing information about career opportunities that come with passing the subject.*
- *Explain real-life application of mathematics in everyday life.*
- *Let the learner write down and give their targets (learners' targets).*
- *Tell learners that the assessment is for CASS (continuous assessment); it encourages the learners to work without supervision.*
- *Share successful mathematics testimonies with the learners and inform them that everyone is different; they may come up with methods of their own.*

All the teachers' ideas above are relevant parts of the support system for retention and revision strategies. All the teachers' ideas seem to point to intrinsic motivation for learning mathematics which aids prolonged retention. The teachers' ideas are consistent with the democratic and constructivist principles on which learner-centred education is established where the focus of instruction is shifted from the teacher to the learners. The shift allows for environments where teachers are only facilitators and providers of experiences, guiding learners to their own discoveries while learners construct knowledge, taking responsibility for their learning (Malan, 2000:26) which contributes more to learning and retention.

v) Teachers' opinions on monitoring of practice work

- *Give them homework and check if it's done the next day.*
- *To make sure they do the work, of course, they know that I will check the work the following day or they must submit the work that they were working on.*

- *Ask learners to present their homework/tasks in class in their groups.*

- *The practice is determined by the learning objectives and competencies based on the syllabi.*
- *I choose challenging practice problems based on the level of understanding shown by the learners on the topic.*
- *I choose challenging practice problems based on the topic taught.*
- *I choose challenging practice problems based on the intelligence of the learners in class, considering the level of the learners (e.g. core, extended and higher level).*
- *I sometimes use the internet for most extreme question papers as they follow almost the same syllabi as the Namibian syllabus content.*
- *The main source of practices is the textbooks and past question papers and other educational programmes. I also use the internet for those who have access and the most asked questions in the external examinations.*
- *I use the prescribed text books and consider the availability of sources of information available to my learners.*

Practice work is work or problems that are given to the learners as activities or tasks intended to consolidate previously learned work (Julie, 2011:4). The teachers' opinions above indicated some of the relevant general ways that can contribute to the effectiveness of retention and revision strategies.

The first three points above point to homework and the rest of the ideas are mainly focused on the nature of work given to learners (how, when and why). The idea of homework is one of the ways for learners to revise work that has been done during the class. However, Julie suggests 'productive practice' which entails 'spiral revision' and 'deepening mathematical thinking' (Julie, 2011:4; Julie, 2013b: 7-12; Okitowamba, 2018:2) is effective even in the cases where learners are hesitant about doing homework. 'Productive practice' entails that learners regularly revise past work by doing short sets of activities and exercises ('spiral revision') and these exercises and activities provide opportunities for understanding, for learners to justify their solutions ('deepening mathematical thinking') and the nature of these activities and exercises are more or less like the one ones in national examinations. This is how examination-driven teachings is made meaningful. According to Julie, productive practice is done at least three to four periods a week for at least ten to fifteen minutes of a period; in this way the teachers can monitor the work that is supposed to be done through homework in class and see that it is done by all the learners. These activities cover previously learned work implying that revision is distributed and not only focused on one topic at a time (Julie, 2011:4).

4.4.3.2.2 Teachers' responses to challenges facing the teachers in the process of addressing the forget problem.

Similarly to all other themes from the open-ended part of the questionnaires, the researcher clustered the comments of all ten the teachers and came up with a summary of their responses regarding the challenges they face. Below are the challenges obtained from the teachers' comments:

Firstly, the teachers' challenges included time constraints due to too much administration work, work overload, tight timetables, unrealistic management of teacher to learner ratios, and limited time for covering the curriculum. Due to time constraints teachers do not manage to study nor incorporate retention strategies well in their classrooms and that is how 'the forget problem' occurs. Secondly, teachers stated that there's a lack of motivation and they work with minimal support from the education officers. They believe that there is supposed to be some forms of motivation such as funding or opportunities to further their studies or to study more on retention and revision strategies as a way to deal with learners' 'forget' problem. Thirdly, teachers found lack of physical resources such as teaching aids to be one of the challenges contributing to the problem of forgetting as this problem contributes to poor application of retention and revision strategies. Lastly, teachers indicated that their professional pre-service training institutions did not train them regarding retention strategies.

Too much administrative work for teachers is one of the top challenges constraining teacher research or studies, especially in Namibia. The teachers also work under pressure to cover overloaded curriculums. The Namibian teachers also highlighted lack of motivation and minimal support from educational offices. All these challenges listed above are consistent with the sentiments below.

According to Robinson (2009), some of the challenges that teachers face are tight work schedules and timetables. The work load is overwhelming and there is no time left for studies or proper collaborative involvement of teachers. The other challenge is poor leadership and there is no body that rewards research in teaching. Unhealthy relationships among colleagues exist in the schools, preventing teachers from engaging collaboratively. Teachers are reluctant about sharing their ideas as the department of education takes their ideas without acknowledgement of the owner. There are few systems and no coordination at an organizational level for teacher idea sharing. One more challenge is that in most schools, but especially in public schools, teachers are computer illiterate and have no library facilities in their vicinities. Finally, according to Buschman (2004:306), teachers are expected to teach and demonstrate skills to learners that their former professional training programmes could not prepare them to do. Because of the reasons listed above, teachers mostly use retention and revision strategies ineffectively. As a result, 'the forget problem' occurs daily and retention disappears with time. The more the gap between the latest learning session and the test is delayed, the more learners forget (Rohrer & Taylor, 2006).

4.4.3.2.3 Teacher comments on ways of studying retention strategies

As stated earlier, from the questionnaires the researcher clustered, the answers of all ten teachers on ways of studying retention strategies appeared alike and generalised samples/extracts of teachers' comments pointed to the same aspect. Below are the teachers' extracts of the ways they think would help teachers study retention and revision strategies.

- *Doing more research.*
- *Sometimes teachers can interact with colleagues and share.*
- *Reading methodological books or searching on the internet.*
- *Personally watch videos showing and demonstrating how certain topics should be introduced.*
- *As a teacher you are a learner too; every year you have to try and find a better way to explain the same content to different children because they are unique individuals.*
- *Use of You Tube videos and xtreme website.*

From the first bullet above, teachers appear to believe that studying retention and revision strategies can be achieved through research. The teachers' comments seem to acknowledge the idea that research is the way for discovering new or collecting old facts (Gough, 2008:2). Research is a natural part of teaching (Fischer, 2001). The teachers' comments appear to confirm that the driving force of the will to find ways on how to upgrade the academic opportunities for learners can be a strong force behind teacher research (Robinson, 2009). Poor academic achievements, the sense of wanting to see things improve in the school, the community or even the country at large can trigger the teachers' will to do research (Robinson, 2009). Teachers can study and research through pre- and in-service face-to-face or distance education where they are unable to take part in face-to-face education (Beldarrain, 2006:139).

Regarding the second point, teachers seem to support the idea that teachers and educators could benefit from collaboration work, where teachers and educators in Namibia could interact and work together for collaborative inquiry or to design teaching and learning materials and work on projects that could help with retention and revision (Robinson, 2009). School-based projects also assist teachers in creating and developing groups of practice in their specialization areas (Robinson, 2009). The rest of the comments in the bullets above indicate teachers' possible ways of studying ideas on retention strategies, which can be brought to collaboration work. 'Teaching is a cultural activity' (Stingler & Hiebert, 1998:2). Like more other cultural activities, teaching skills are acquired through non-formal engagement over a length of time. A combination of good teachers, practices and methods of teaching are what make a great impact on the students' achievement (Christie at al., 2007).

4.4.3.2.4 Teacher responses on how learners' retention can be improved

The teachers' opinions on how to improve learners' retention highlighted the need for strong leadership and support from education officers and the government in terms of human, financial and physical resources. They believe that this kind of support would solve problems regarding time constraints, further studies and relevant teaching resources.

From the teachers' views, practically all teachers can be provided with opportunities to improve learners' retention of school mathematics. The teachers' comments gave an impression that the issue of improving learners' retention in Namibia has to be approached, starting from mathematics subject policies, curriculum and assessment. Staffing policy norms can be amended for more human resources to avoid tight work schedules and timetables for teachers. According to the National Mathematics Subject Policy Guide the Namibia school mathematics view of assessment is almost entirely focused on one topic at a time (See 2.7). As a result, learners are only faced with mixed problems (where the choice of procedures is not obvious) during high-stakes examinations (examinations that determines learners' progression to the next grade). They are then confronted with something new and unfamiliar (Rohler & Tylor, 2007:485). Learners struggle therefore and might fail.

According to Julie (2013b:4) and Okitowamba (2018:4), Bishop, Hart, Lerman and Nunes (1993; 11) contend that "examinations operationalise the significant components of the intended mathematics curriculum, so they tend to determine the implemented curriculum. Burkhardt and Pollak (2006) and Vanden Heuvel-Panhuizen and Becker (2003) argue that teaching will always be governed and regulated by examinations (what is examined) (Julie, 2013b:4). The reseacher's opinion is that teachers should consider the intended and the interpreted curriculum as just that, to govern the extent of the content to be done but the implemented curriculum (their implementation of the curriculum) should be governed by the examined curriculum (Julie, 2013b; Okitowamba, 2018:4).

The ideas of 'spiral/regular revision' (LEDIMTALI project's version of distributed practice) and 'deepening mathematical thinking' (Julie, 2011:4), and 'exam-driven teaching' (Julie, 2013b:13; Okitowamba, 2018:4) will open boundaries to deal with mathematics instruction as required by meaningful learning (see 2.3.2). "Spiral revision' and 'deepening mathematical thinking' (productive practice) are some of the elements of *meaningful teaching* that are included in 'exam-driven teaching' for *meaningful learning* (Julie, 2013b:7). Julie (2013b:10-14) and Okitowamba (2018:2) refer to professional development activities on pedagogical affairs such as teachers discussing lesson excerpts; working on mathematical problems to enhance their 'mathematicalness' (flexible ways of dealing with or managing mathematics); and then discussing how they can get their learners engaged with mathematics; as well as discussing about dilemmas that teachers are faced with in their teaching and ways of addressing them. These are ideas that can help with improving learners' retention in Namibia.

As stated in the methods chapter, during classroom observations, teachers who were found to be demonstrating more explicit revision and retention strategies were intentionally and purposefully identified (see section 3.7.1.3). By the end of the observations the researcher later in the process switched from a non-participant to a participant observer by sharing some of the revision strategies that the researcher found most effective, based on the theoretical perspective in Chapter 2. This was done with the participants who seemed to apply more explicit retention and revision strategies only.

All of these four teachers were encouraged to create a platform, such as mini-workshops, to share their individual experiences and strategies from the observation period. The researcher also compiled a small handbook on retention and revision strategies which she gave to all ten the participant teachers which was part of the tokens of appreciation before departure. This was done so that the learners who were not exposed to more explicit strategies would also get an opportunity to benefit from the intervention.

4.5 CONCLUSION

The chapter has covered the discussion and analysis of the study's findings. The data produced through face-to-face interviews, questionnaires, and classroom observations were examined. By examining the data, the researcher discovered that the teachers have the fundamental understanding and use retention and revision strategies in their teaching though they need to explore more about effective teaching retention and revision strategies that can improve learners' retention in secondary school mathematics. The results revealed that the teachers perceive retention and revision strategies as that help learners remember and crucial in the teaching of mathematics. The teachers in this study have different strategies of their own. It appears that the teachers are doing something towards helping the learners deal with forgetting.

From the study results, the main research question as well as the sub-questions appears to have been dealt with theoretically and empirically. The sub-questions 1-4 were addressed more through the literature, Interviews and questionnaire results. The sub-questions 5-6 were addressed by the classroom observation results and the questionnaires results or answers pointed more to answering the sub-questions 7-10.

The researcher noted that there is some misalliance between what some of the eight selected participant teachers advocated through the interviews and their practices in their classrooms. Teachers appear to have gained some understanding of the theoretical views about retention strategies but the implementation aspect can be a struggle. This might be brought about by some of the challenges stated by the participant teachers in the study.

The theories behind the concepts of retention and revision strategies could also contribute to effective use of retention and revision. The researcher believes that features entailed by a definition of a certain concept are necessary for deep insight and application of an idea. Thus, teachers could be encouraged to learn more about retention and revision strategies. From this study, it appears that teachers in the study have recognised the significance of teaching using retention and revision strategies. The intervention seems to have made the teachers more aware of such revision and retention strategies. Teachers appeared to have been triggered, and are eager, and looking forward to finding their means to implement the learning and teaching of school mathematics through retention and revision strategies.

The following chapter delineates the summary, recommendations, implications, and limitations of the study.

CHAPTER 5

CONCLUSIONS AND IMPLICATIONS

5.1 INTRODUCTION (conclusion)

This chapter reviews the summary, conclusions, and implications of the study. Conclusions are established on empirical research findings and related to the reviewed literature discussed in Chapter 2 of this study. Some implications for facilitating senior secondary school mathematics using retention strategies are identified. Some limitations encountered in the study are also identified. Finally, based on the study's empirical findings, some recommendations are also provided.

5.2 CONCLUSIONS

According to the literature review and empirical findings presented in Chapter 4 of the study, some conclusions regarding teachers' experiences with retention and revision strategies can be drawn.

After consulting the literature, it was discovered that the fundamental aspect underpinning learners' knowledge retention in school mathematics, and thus the solution to the forget problem, is meaningful learning. Meaningful learning holds the two most important objectives of education that make up a complete cognitive process which are '*retention*' and '*transfer*' (Mayer, 2002:226). The literature pointed to the importance of meaningful learning which means learning with deep understanding or insightful learning in opposition to 'rote learning' which means learning with little or only superficial understanding. The findings of this study have shown that the teachers' classroom teaching practices pointed predominantly to rote learning.

The literature highlighted that meaningful learning is achieved through assessment and teaching strategies that use cognitive processes of 'remember' through retention/memorization strategies and 'transfer' of knowledge through revision strategies. The main objective of meaningful learning is to extend teacher instruction and assessment beyond a single cognitive process of *remembering* (Mayer, 2002:232).

Even though retention strategies and revision strategies can be viewed as two separate methods, they are interdependent strategies. While each has its distinctive unique features, they cannot be conceived of or play in isolation from one another within the context of retention. Successful reciprocity between these two main strategies is crucial for meaningful learning, and a way to deal with ‘the forget problem’. The findings of this study suggest that memorization strategies dominated the teachers’ assessment and instruction strategies. The reasons for the statement above are discussed below.

While the eight teachers who took part in the classroom observations appeared to be enthusiastic about retention and revision strategies and intended to apply these practices in the classrooms, they still proceeded to teach predominantly without using them. Chapter 2 clearly indicated that retention strategies and revision strategies are reinforced through learner-centred approaches, whereby learners are problem solvers and do most of the work (also see 4.4.2.1). The findings imply that the teachers are still facilitating mathematics mostly using teacher-centred approaches (see 4.4.2.1.1). Numerous studies have referred to this approach as ‘traditional approaches’ (‘telling and showing’) where teachers tell and show while learners passively listen, or emulate and follow. As argued by Wertheimer, cited in Schoenfeld, 1987:3), the knowledge gained through such procedures is likely to be only superficial, inflexible, or not useful. Ordinarily, shallow information is barely retained. According to Julie (2011), it is acknowledged that the main cause of low achievement in examinations or even tests is non-retention of knowledge.

The study results showed that some of the interviews and questionnaire results did not correlate well with the classroom observational results. There seemed to be quite a disparity or mismatch between what took place in the classrooms and what most of the teachers advocated for. In the classrooms, teachers talked most of the time and frequently mediated to demonstrate to the learners how to go about solving mathematical problems. The teachers mostly dominated the classroom discussions and little was done to promote both retention and transfer. The two most important goals of education are ‘*promote retention*’ and ‘*promote transfer*’ (Mayer, 2002:226).

The study findings prove that the teachers have fundamental knowledge, use and are enthusiastic about using retention and revision strategies in their classrooms more. They have shown willingness to adapt to the paradigm shift from the common traditional approach to meaningful learning. Nevertheless, teachers are still experiencing challenges to fully implement retention strategies (see 4.4.2.2). As indicated in studies such as that of Julie (2011), it was found that some teachers have adjusted to ‘productive practice’ procedures. It has therefore been proven that teachers can use and adapt to using retention and revision strategies to improve learners’ retention of school mathematics should they be provided with opportunities. The study results have also revealed that retention and revision strategies have a positive influence on the learners’ mathematics achievement scores.

The empirical findings and findings from the reviewed literature indicated time constraints and lack of opportunities for teachers to deepen their thinking on mathematics as the main obstacle to addressing the ‘forget problem’. Tight work schedules and timetables for teachers are not an exemption to the challenges that teachers experience (Robinson, 2009). The comments from the teachers indicated that they work under pressures to cover the loaded mathematics curriculum and work with minimal support from education officers. However, regarding the aspect of time, the teachers too appear to have slipped into an idea that the procedures adopted and the knowledge and skills secured in dealing with a particular problem (through meaningful learning) may be transferred (applied) to other new problems and by that, the factor of time could be addressed. This incorporates the view of Buschman (2004:304) that no single problem is entirely solved, and there may forever be an advanced perception of an answer or a solution.

Furthermore, the findings of the study indicate that teachers need to make an effort to work on aligning the policy statements (the intended curriculum), curriculum (how/what they teach) and the examined or assessed curriculum. Dealing with mathematical instruction as required by meaningful learning can assist with addressing the time issue. For example, incorporating the ideas of ‘spiral/regular revision’ (LEDIMTALI project version of distributed practice) and ‘deepening mathematical thinking’ as some of the valued components of meaningful learning in ‘examination-driven teaching’ (Julie, 2013b:7), can save a great deal of time, by aiding teachers who use examination-driven teaching to cover a balanced and rich content within a limited time (Okitowamba, 2018:4). Examination-driven teaching contributes towards meaningful learning (Julie, 2013, cited in Okitowamba, 2018:4). “Examinations constitute legitimate and valuable mathematics knowledge of the intended mathematics curriculum, so they tend to determine what the teachers teach, the implemented curriculum” (Bishop, Hart, Lerman & Nunes, 1993:11, cited in Julie, 2013b:4 and Okitowamba, 2018:4). Teaching will always be regulated by examinations (what is examined) (Burkhardt and Pollak, 2006; Van den Heuvel-Panhuizen & Becker, 2003, cited in Julie, 2013b:4). The opinion of the researcher is that teachers should not only regard the intended and the interpreted curriculum to indicate the extent to which the content should be done but how and what they teach (the implementation of the curriculum) should comply with the examined curriculum (Julie, 2013b; Okitowamba, 2018:4). Teachers should also make efforts to reconsider their instruction strategies to competently prepare learners to meet the curriculum requirements.

The findings revealed that the teachers commonly used the textbooks as teaching materials, which are made up of a compilation of examples with succeeding activities. This design, in particular, may not fully equip the teachers with the needed opportunities and skills to improve their mathematical thinking and accompanying teaching strategies (Rohler & Tylor, 2006). This design appears to promote more rote learning than a deep understanding by the learners. The teachers, however, appear to be comfortable with their teaching aids, ‘the textbook’, which may as well be associated with their hardships in dealing with the 'forget problem'.

The conclusions above have implications for senior secondary school mathematics teaching using retention and revision strategies and further research based on the research questions.

5.3 IMPLICATIONS

The results and conclusions of this study may have some implications in at least five domains for mathematics teacher education. These include pre-service training, in-service training, classroom practices, collaboration work, and future research.

5.3.1 Implications for pre-service education programmes

The findings of the study suggest that more opportunities should be included within the teaching of school mathematics to ensure that teachers communicate mathematics to the learners in the best possible effective ways. The researcher can make the statement for the reasons discussed below.

The findings indicate that the facilitation of senior secondary mathematics has to incorporate more opportunities for improving retention and revision strategies. Mathematics teaching using retention strategies could be executed better by teachers that were tutored at tertiary institutions or lecturers through the same practices. This way the teachers can be expected to facilitate mathematics in their classrooms by using retention strategies. Thence, if a positive attitude and expertise towards mathematics teaching via retention and revision strategies can be developed fully, promoted, and expanded to mathematics education training programmes, learners' achievement in mathematics may be improved.

The teachers' comments showed that their pre-service professional institutions did not prepare them with regards to retention and revision strategies (see 4.4.3.2.2).

5.3.2 Implications for in-service education training programmes

In-service programmes for secondary mathematics teachers need to include enabling teachers to acquire improved understanding and instructional ideas about retention and revision strategies. The main aim of mathematics education training programmes is to equip teachers with the necessary or improved competencies to help learners develop mathematical problem-solving skills (Stacy, 2005). Such training methods could be provided frequently through teacher in-service education programmes for secondary school mathematic teachers, especially the teachers who were not provided with such opportunities during their pre-service training.

An implication for in-service education could be a convenient training to help senior secondary school mathematics teachers to advance their effectiveness in the classroom using revision and retention strategies. Such in-service programmes should be ones that would create environments that would enable the teachers to develop positive attitudes and competency towards retention and revision strategies. Such environments could also be such that they enable the teachers to deepen their mathematical thinking and communicate mathematics to the learners in a concise, explicit, and logical manner on different and especially advanced topics using retention and revision strategies. It may be necessary to mention that teachers find ordinary once-off workshops insignificant (Buschman, 2004).

5.3.3 Implications for classroom teaching practices

The findings of this study show that meaningful learning is the basis of the retention of knowledge and skills. 'Meaningful learning' provides opportunities where teachers become aware of the intended, implemented and examined curricula and how they impact the schooling system. Moreover, based on the reviewed literature, the findings of this study focus more prominence on memorization and 'productive practice', that is, memorization strategies, 'deepening mathematical thinking' and 'spiral revision'. Teachers should, together with peers and curriculum advisors or regional education department staff, develop the capacity to promote the ideas of memorization strategies, 'spiral revision' and 'deepening mathematical thinking' of the learners to promote both *recalling* and *transfer* of knowledge and skills necessary for meaningful learning. Research has proven that, as with spiral revision, ensuring that learners are engaged with deepening mathematical thinking activities enhances mathematics achievement scores in tests and examinations (Julie, 2011). Deepening mathematical thinking activities are confirmed to enable learners to engage with and do mathematics, which adds more to learning than when learners imitate and follow. The idea of productive practice should be ideal to change the role of the teachers to 'teaching learners to become mathematicians rather than teaching them about mathematics' (Papert, 1972).

'Productive' means 'deepening math thinking' related to the math content. 'Practice' (regular exercises) on deepening mathematical thinking activities enables learners to sustain and improve their mathematics achievement scores in tests and examinations. Mathematical objects have deep and rich meanings that span the operative curriculum, that is, the daily happenings per lesson. Also included here will be the intended, implemented and examined curricula. Teachers cannot do this type of work on their own. They need to work with education department staff, with colleagues in the same school or nearby schools.

Classroom reforms or approaches established in a learner-centred approach as in opposition to a teacher-centred approach have been proven by research to contribute more to learning acquisition. Teachers should, therefore, evolve from the roles of instructors into facilitators.
The approaches discussed above would help the learners to develop their roles as active participants rather than passive imitators and followers.

5.3.4 Implications for collaboration work

The outcomes of this study may have implications for collaboration work for teachers in Namibia to work together with fellow teachers or people from the directive offices (educators) or even international educators to design learning and teaching materials and work on projects that can help with revision and retention. These may incorporate instances where individuals would present to each other how they would present certain topics to their learners using retention and revision strategies after they have done more in-depth research on the particular topics, especially Grade 11 and 12 advanced topics. These projects could, for instance, be a local cluster, regional, or even university-based and aimed at the improvement of teaching and learning mathematics with a special focus on 'retention'.

5.3.5 Implications for future research

This study has presented some issues that are crucial to mathematics facilitation that is in opposition to transmission of mathematics knowledge, to assist or guide learners to get involved in their own learning while using retention strategies. This study, therefore, could potentially open the way for future studies concerning the challenges senior secondary school mathematics teachers are faced with in the process of addressing the forget problem in their teaching. A suggestion for future study could be an extensive study to determine the factors hindering secondary teachers from fully developing retention and revision strategies in their teaching. Establishing plans to help teachers concerning effective implementations of retention and revision strategies in their classrooms can be done as well. This specific study would clearly illustrate the sanctioned challenges as well as procedures or a plan of action to be taken.

A more detailed study of the relevance and value of contact block classes, proper and regular classroom support visits, and fortnightly training workshops may also provide helpful knowledge for further improvements of the Namibian education in-service efforts and help with retention and revision strategies. There is a need for school mathematics teachers teaching methods to be researched and re-analysed to make room for problem-solving and a constructivist aspect of learning mathematics (Schifter & Simon, 1993).

5.4 LIMITATIONS

This study was limited to senior secondary school mathematics teachers from the Oshivelo circuit in the Oshikoto region of Namibia. This study was limited to grades 11 and 12. Despite the limitations, the data produced for this study addressed critical aspects to contribute towards a better insight into the perceptions and experiences of senior secondary school mathematics teachers teaching mathematics and applying retention strategies.

5.5 CONCLUSION

This study has presented how Namibian senior secondary school mathematics teachers perceive and experience the benefits and challenges of incorporating retention and revision strategies in their teaching. Notwithstanding the limitations of the case study, the researcher managed to observe a positive change in the attitudes and approaches of the participants towards the usage of retention strategies.

Nonetheless, it has to be noted that adoption of retention and revision strategies by teachers will not be a short-term investment or be accomplished overnight. Previous research has shown that education reforms require a lot of effort. The work of reform demands large investments of funds, time, and energy (Berry III & Ellis, 2005:14). Also, reform productivity will depend on how other mathematics educators will collaborate with mathematics teachers (Berry III & Ellis, 2005:7). It may require a progressive approach to convince teachers that their current methods are less effective or relevant to the contemporary world or even to convince them that facilitating learners through effective retention and revision strategies increases the learners' likelihood of achieving higher test or examination scores. Some opportunities may be established where the teachers successfully participate in or experience the real strategies used to improve retention, in order to convince the maximum number of teachers.

Furthermore, teachers need to do more critical self-evaluations and reflect on their teaching practices more often. The researcher contends for regular contact block classes, classroom support observations/visits, and routine workshops for senior secondary mathematics teachers, established on retention and revision strategies in senior secondary school mathematics teaching, as perhaps a means to enhance the quality as well as achievement in school mathematics. The only way this can materialise is if tertiary institutions, teachers, and the schools as bureaucracies can synergistically gather their resources and efforts towards achieving the aforementioned outcome.

It is evident for the researcher that to accomplish an improved achievement and quality mathematics education in Namibia requires a long-term investment of money, energy, and time. However, we have explored the implications and the potential that the retention and revision strategies have in improving how our learners experience achievement in school mathematics. We should, therefore, while we undertake this work of reform, find comfort and courage in thinking about how the future would look like when learners of various backgrounds develop a meaningful understanding of mathematics (Berry III & Ellis, 2005:14). To be concise, we should not worry or concentrate about the processing but rather about the product we anticipate. As expressed, the education department and teaching staff need to make an effort to review the relevant mathematics curriculum and different teaching strategies to effectively help and prepare learners to meet both the curriculum and societal requirements. While not justifying being precisely sure about what that future may look like for society, at least we are optimistic it will be less biased than the one of today (Berry III & Ellis, 2005:14).

REFERENCE LIST

A Comparison of Teacher-Centred and Student-Centred Approaches in Education. *International Journal of Social Sciences & educational Studies*, 5 (1): 164-166.

Algarabel, S. & Dasi, C. 2001. The definition of achievement and construction tests for its measurements: A review of the main trends. *Pscicologica*, 22:43-66.

Anthony, G. & Walshaw, M. 2009. Characteristics of effective teaching of mathematics: A view from the West. *Journal of Mathematics Education*, 2(2): 147-164.

Anthony, G. & Walwash, M. 2008. The teacher's role in classroom discourse: A review of recent research into mathematics classrooms. *Review of Educational Research*, 78 (3):516-551.

Artzt, A.F., Armour-Thomas, E. & Curcio, F.R. 2008. *Becoming a reflective mathematics teacher: A guide for observations and self-assessment*. 2nd edition. New York: Lawrence Erlbaum.

Ary, D., Jacobs, L.C., Razavieh, A. & Sorensen, C. 2006. Introduction to research in Education. 7th Ed. Canada; Thomson Wadsworth.

Babbie, E. 2017. The basic of social research. 7th Ed. Boston: Cengage Learning.

Baggaley, J.1995. Where did distance education go wrong? *Distance Education*, 29 (1):39-51.

Baker, M.J. 2015. Collaboration in Collaborative Learning. *Interactive Studies*: *Social Behavior and Communication in Biological and Artificial Systems*, 16 (3), November: 451-473.

Beldarrain, Y. 2006. Distance Education trends; Integrating new technologies to foster student interaction and collaboration. *Distance Education*, 27(2): 139-153.

Berry III, R. Q. & Ellis, M.W. 2005. The Paradigm Shift in Mathematics Education: Explanation and Implications of Teaching and Learning. *The Mathematics Educator*, 15 (1):7-17.

Bih, N. L., Asyikin N. & Hassan, B. 2019. The Use of Mnemonic and Mathematical Mnemonic Method in Improving Historical Understanding. International Journal of Educational and Pedagogical Science, 13 (2), February: 93-97.

Bobis, J., Anderson, j., Martin, A. & Way, J. 2011. *A model for mathematics instruction to enhance student motivation and engagement. Motivation and disposition: Pathways to learning mathematics.* 73rd Yearbook. Reston: National Council of Teachers of Mathematics.

Bogdan, R. C. & Biklen, S. K. 2006. Qualitative research for education: An introductory to research and methods. 5th edition. Needham Heights, MA: Allyn and Bacon.

Brahier, D.J. 2011. Motivation and disposition: The hidden curriculum. *Pathways to learning mathematics*, (2011):1-8.

Brayda, W. C & Boyce, D. T. 2014. So You Really Want To Interview Me?: Navigating “Sensitive” *Qualitative Research Interviewing. International Journal of Qualitative Methods*, (13): 318-334.Credibility of Research Results. 2011. [Online] Available: http://credibility-rsmet.blogspot.com/ensuring-credibility-of-qualitative.html [2011, November 30].

Bryman, A. 2007. The Research Question in Social Research: What is its Role?, International Journal of Social Research Methodology, 10 (1):5-20.

Buschman, L. 2004. Teaching problem solving in mathematics. *National Council of Teachers of Mathematics*. 10 (6): 302-309.

Carpenter, S.K., Cepeda, N.J., Rohrer, D., Kang, S.H.K & Pashler, H. 2012. Using Spacing to Enhance Diverse Forms of Learning: Review of Recent Research and Implications for Instructions. *Educational Psychology Review*, 24:369-378.

Chadwick, B.A., Bahr, H.M. & Albrecht, S.L.1984. *Social science research methods*. New Jersey: Prentice-Hall.

Christie, P. 2008. Schools and classroom as places of learning. In *opening the doors of learning*. (Heinemann, Cape Town).

Cockcroft, W. H. 1982. *Mathematics count*. Report of the committee of Inquiry into the Teaching of Mathematics in Schools under the chairmanship of W.H. Cockcroft.Retrieved from:http//.educationengland.org.uk/documents/cockcroft1982.html [12 September 2013].

Cockcroft, W.H.1982. *Mathematics count*. Report of the Committee of Inquiry into the Teaching of Mathematics in Schools under the chairmanship of W.H. Cockcroft. Available: http://www.educationengland.org.uk/documents/cockcroft1982.html [12 September 2013].

Cohen, L., Manion, L. & Morrison, K. 2000. *Research in education*. Fifth edition. London:Routledge.

Cohen, L., Manion, L. & Morrison, K. 2007. *Research in education*. Sixth edition. London:Routledge.

Cole F.L. 1988. Content analysis: process and application. *Clinical Nurse Specialist*, 2(*1*), 53–57.

Connelly, L.M. 2016.Trustworthiness in Qualitative Research. *Medsurg Nursing*, 25(6), November-December: 435-436.

Connole, H. 1993. The Research Enterprise in Issues and Method in Research: Study Guide. Adelaide: University of South Australia.

Corbin, J. & Strauss, A. 2008. Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory. 3rd edition. Thousand Oaks, CA: Sage.

Cresswell, J. 2015. *A concise introduction to mixed methods research.* Los Angeles: Sage.

Cresswell, J. W. 2013. Qualitative inquiry and research design: Choosing among five approaches. Thousand Oaks, CA: Sage.

Creswell, J. W. 2007. Research design: Qualitative and quantitative approaches. 2nd ed. Thousand Oaks, CA: Sage.

Creswell, J. W. 2012. Educational Research: Planning, Conducting, and Evaluating quantitative and Qualitative Research 4th Ed. Lincoln: Pearson.

D'Ambrosio, B.S.2006. Teaching mathematics through problem solving: A historical perspective. In H.L. Schoen & R.i. Charles (eds.). *Teaching mathematics through problem solving: Grade 6-12*. United States of America: Library of Congress, 39-52.

D' Emiljo, K. 2012. $y = mx + c$ to success: Mathematics Namibia. Ordinary Level: Grade 11& 12 Core & Extended. John Meinert: Windhoek.

DeLashmutt, K. 2007. A Study of the Role of Mnemonics in Learning Mathematics. Lincoln: University of Nebraska [Online] Available: http//digital commons.unl.edu/mathmidsummative.

Denzin, N. K., & Lincoln, Y.S. (eds.). 2005. Handbook of qualitative research. 3rd ed. Thousand Oaks, CA: Sage.

Driver, R. & Oldham, V.1986. A contructivist approach to curriculum development. *Studies in Science Education*, 13:105-122

Fischer, J. 2001. Action Research rationale and planning: developing a framework for teacher inquiry. In G. Burnaford, J. Fischer & D. Hobson (eds). Teacher Doing Research: The power of Action Through Inquiry. New Jersey: Lawrence Erlbaum.

Franke, M.L. & Kazemi, E. 2001. Learning to teach Mathematics: Focus on student thinking. Theory into Practice, 40(2)102-109.

Franke, M.L. Kazemi, E & Battery, D. 2007. Mathematics teaching and classr9oom practice. In F.K Lester, Jr., (Ed.), Second Handbook of Research on Mathematics Teaching and Learning (pp.225-256). Charlotte, NC: Information Age Publishing.

Freebody, P.2004. *Qualitative research in education*: *Interaction and practice*. London: Sage.

Githua, B. N. & Nyabwa, R. A. 2008. Effects of Advance Organiser strategy during instruction on secondary school students' mathematics achievement in Kenya's Nakuru District. International Journal of Science and Mathematics Education, 6:439-457.

Glaser, B. G., & Strauss, A. L. 1997. The discovery of Grounded theory: Strategies for qualitative research. Hawthorne, NY: Aldine.

Gough, N. 2000. Methodologies under the microscope. 2000 Conference proceedings. 8 October, Dublin, Ireland. Dublin University Photography Association (DUPA): Deakin Centre for Education and Change [Electronic].

Gough, N. 2000. Methodologies under the microscope. Dublin: Dublin University Photography Association (DUPA), Deakin Centre for Education and Change.

Grouws, D. A. 2006. The teacher's role in teaching mathematics through problem solving, in H.L. Schoen, & R.I. Charles, (eds). *Teaching mathematics through problem solving: Grades 6-12.* United States of America: Library of Congress Cataloging-in-Publication Data. 129-141.

Gunawan, J. 2015. Ensuring Trustworthiness in Qualitative Research. Belitung Nursing Journal, 1(1), November-December: 10-11.

Gunston, R. 2015. Meaningful learning. *Encyclopedia of Science Education,* 1007 (978): 626-685.

Gustafsson, J. 2017. Single case study vs. multiple case studies: A comparative study. Halmstad University [Electronic]. Available: http://www.diva-portal.org/smash/get/diva2:1064378/FULLTEXT01.pdf [2017, January 12].

Habermas, J.1972. *Knowledge and human interests*. London: Heinemann.

Hanse-Himarwa, K. 2018. The 2017 Grade 10 Junior Secondary Certificate (JSC) and Grade 12 Namibia Senior Secondary Certificate (NSSC) Higher level results [Press release] [Electronic]. Available: http//www.nied.edu.na

Hayes, D.1995. In-service training teacher development: some basic principles. *ELT Journal*, 49 (3), July:252-261.

Hiebert, J., Carpenter, T.P. 1992. Learning and teaching with understanding. In D.A. Grouws (ed). *Handbook of research on mathematics teaching and learning*. New York: Macmillan, 65-95.

Henning, E., Van Rensurg, W. & Smit, B. 2004. *Finding your way in qualitative research.* Pretoria: Van Schaick.

Hiebert, J. & Wearne, D. 2006. Developing understanding through problem solving, in H.L. Schoen, & R.I. Charles, (eds.). *Teaching mathematics through problem solving: Grades 6-12.* United States of America: Library of Congress Cataloging-in-Publication Data. 3-13.

Hogue, E. 2019. Memorization: A Proven Method of Learning. *International Journal of Applied Research*, 22, February:145-150.

Julie, C. 2013a. Towards a model for intentional teaching for improving achievement in high-stakes mathematics examinations. In Z. Davis & S. Jaffer (Eds.), *Proceedings of the 19th Annual National Congress of the Association for Mathematics Education of South Africa* (Vol. 1., pp. 86–96). Cape Town: AMESA. Retrieved from http://www.amesa.org.za/AMESA2013/Files/P11.pdf

Julie, C. 2013b. Can examination-driven teaching contribute towards meaningful teaching? In D. Mogari, A. Mji & U.I. Ogbonnaya (eds.), *Proceedings of the ISTE International Conference on Mathematics, Science and Technology Education: Towards effective teaching and meaningful learning in mathematics, science and technology'* Pretoria: UNISA Press. Pp. 1–14.

Julie, C. 2011. LEDIMTALI Brochure. Bellville: University of the Western Cape.

Julie, C. 2019. *A story of encounters of learners with aspects of integer arithmetic embedded in deepening mathematical thinking tasks* [Online]. Available: http://amesa.org.za/AMESA2019/Proceedings.htm [2019'July 1-5].

Kambowe, K. 2018. ‘School with 0% pass rate’. *Namibian Sun*, 16 January 2018: 3.

Kang, S.H.K. 2016. Spaced Repetition Promotes Efficient and Effective Learning: Policy Implication. Policy Implications for Instruction. *Policy Insights form the Behavioral and Brain Science*, 3(1):12-19.

Kester, L., Kirschner, P. A., & Van Merriënboer, J. J. G. 2004. Timing of information presentation in learning statistics. *Instructional science*, 32:233-252.

Kilpatrick, J., Swafford, J. & Findell, B. (Eds). 2001. *Adding it up: Helping children learn mathematics*. Washington, DC: National Academy Press.

Kirkman, G. & Shaw, E. L. 1997. *Effects of an oral advanced organizer on immediate and delayed retention* (Report No. TM02960). Washington, DC: Office of Educational Research and Improvement. (ERIC Document Reproduction Service No. ED415263).

Koehler, M.S. & Grows, D.A.1992. Mathematics teaching practices and their effects. In D.A. Grows (ed.). *Handbook of research on mathematics teaching and learning*. New York: Macmillan, 115-126.

Kolb, S. M. 2012. Grounded Theory and the Constant Comparative Method: Valid Research Strategies for Educators. Journal of Emerging Trends in Educational Research and Policy Studies, 3 (1):83-86.

Kolb, S. M.2012. Grounded Theory and the Constant Comparative Method: Valid Research Strategies for Educators. *Journal of Emerging Trends in Educational Research and Policy Studies (JERAPS)*, 3(1):83-86.

Kombo, D.K. & Tromp, D.L.A. 2006.*Proposal and thesis writing: An introduction.* Nairobi: Paulines.

Kowal, S. & O’ Connel, D. C. 2004. The transcription of conversations. In U. Flick, Kardorff von E. & I. Steinke (Eds). A companion to qualitative research. London: Sage.

Kuhn, T. S. 1996. The structure of scientific revolutions. Third edition. Chicago, IL: University of Chicago Press.

Kvale, S. & Brinkmann, S. 2009. *InterView: Learning the craft of qualitative research interviewing.* Los Angeles: Sage.

LaBanca, F. 2010, May 30. In the search of scientific creativity. [Electronic]. Available: http://problemfinding.labanca.net/2010/05/ [2010, May 30].

Lankshear, C. & Knobel, M. 2005. *A handbook for teacher research: From design to implementation*. New York: Open University Press.

Lather, P. 1991. *Feminist research in education*: *within/against*. Geelong: Deakin University Press.

Lau, P. N. K., Singh, P. & Hwa, T.Y. 2009. Constructing mathematics in an interactive classroom context. *Educational Studies in Mathematics*, 72 (3):307-324.

Le Grange, L & Beets, P. 2005. (Re) conceptualizing validity in (outcome-based) assessment. *South African Journal of Education*, 25(2)115-119.

Le Grange, L. 2014. Bed Hons Education Researcher. Stellenbosch. SunMedia.

Le Grange, L. 2014. Bed Hons Education Researcher. Stellenbosch. SunMedia

Le Grange, L. 2017. Decolonising/indigenous methodologies. In Ramrathan, Labby, Le Grange, Lesley and Higgs, P. (Eds.). *Education studies for initial teacher development*. Lansdowne: juta. Pp.456-469 (ISBN: 978-1-48510-266-3).

Le Grange, Lesley. 2017. Decolonising/indigenous methodologies. In Ramrathan, Labby., Le Grange, Lesley and Higgs, P. (Eds.). *Education studies for initial teacher development*. Lansdowne: juta. Pp.456-469 (ISBN:978-1-48510-266-3).

Lesh, R. & Doerr, H. M. 2003. Foundation of a models and modeling perspective on mathematics teaching, learning and problem solving. In R. Lesh & H.M. Doerr (Eds). *Beyond contructivisim: Models and modeling perspectives on mathematics problem solving, learning and teaching.* Mahwah, NJ: Lawrence Eelbaum, 3-33.

Locke, K. 1996. Rewriting the discovery of grounded theory after 25 years? *Journal of management enquiry*, 5:239-246.

Malan, S.P.T. 2000. The 'new paradigm' of outcome-based education in perspective. *Journal of Family Ecology and Consumer Sciences*, 28:22-28.

Manoucheri, A. 2007. Inquiry-discourse mathematics instruction. *The mathematics teacher*, 101(4):290-300.

Marcus, R. & Fey, J. T. 2006. Selecting quality tasks for problem-based teaching. In H. L. Schoen & R.I. Charles (Eds.). *Teaching mathematics through problem solving: Grades 6-12*. United States of America: Library of Congress, 55-67.

Marsh, E. & White, M. D. 2006. Content Analysis: A flexible Methodology. *Library Trands*, 55 (1), summer: 22-45.

Mayer, R.E.2002. Rote versus Meaningful Learning, *Theory Into Practice*, [Electronic], 41(4): 226-232 Available: http://www.sciencedirect.com/science [2010, June 24]

Mayer, R.E. 2002. Rote versus Meaningful Learning, Theory Into Practice, [Electronic], 41(4): 226-232 Available: http://www.sciencedirect.com/science [2010, June 24].

Maykut, P and Morehouse, R.1994. Beginning qualitative Research: A Philososophic and Practical Guide. London: The Falmer Press.

McMillan, J. H. & Schumacher, S. 2001. *Research in education: A conceptual introduction*. 5th Edition. New York: Addison Wesley Longman.

Mihajilovic A., Egeric M. & Dejic, M. 2008. Mathematical Abilities: Identification and Development. MATM2017 conference announcement. January, University of Kragujevac. [Electronic]. Available: https://www.researchgate.net/publication/290430034 [2016, January 14].

Miles, M. B. & Huberman, M. A. 1994. *An expanded source book: Qualitative data analysis.* 2nd ed. London: Sage.

Miles, M. B., & Huberman, M. A. 1994. Qualitative data analysis: A source book of new methods. 2nd edition. Newbury Park, CA: Sage.

Nachmias, C. F & Nachmias, D. 1996. *Research methods in the social sciences*. 5th edition. New York: St Martin's Press.

Ndjendja, E. 2018. 13th Annual Mathematics Congress. Directorate of National Examinations and Assessment (DNEA).

Neuman, W.L. 2011. *Social research methods: Qualitative and quantitative approaches.* 7th Ed. Boston: Pearson.

Nieuwenhuise, J. 2001. *The practice of social research*. Cape Town: Oxford University Press.

Novak, J. 1998. Learning, creating and using knowledge. Concept Maps™ as facilitative tools in schools and in corporations. London: Lawrence Erlbaum.

Novak, J. 2002. Meaningful learning: The essential factor for conceptual change in limited or inappropriate prepositional hierarchies leading to empowerment of learners. *Science Education*, 86(4): 548 – 571.

Novak, J. D. 2002. Meaningful Learning: The Essential Factor for Conceptual Change in Limited or Inappropriate Propositional Hierarchies Leading to Empowerment of Learners. *Science Education*, 86: 548-571.

Novak, J. D., & Gowin, D. B. 1984. *Learning how to learn*. New York: Cambridge University Press.

Novotná, M., Hofmannová J., & Petrová, R. 2008. Assessment approaches to teaching mathematics in English a s a foreign language (Czech experience). *International Content and Language Integrated Learning Research Journa*l, 1 (1):20-35.

Okitowamba, O., Julie C & Mbekwa, M. 2018. The effects of examination-driven teaching on mathematics achievement in Grade 10 school-based high-stakes examinations. *Pythagoras*, *39*(1), a377. Available: https://doi. org/10.4102/Pythagoras. v39i1.377.

Okitowamba, O., Julie, C., & Mbekwa, M. 2018. The effects of examination-driven teaching on mathematics achievement in Grade 10 school-based high-stakes examinations. *Pythagoras*, *39*(1), a377. https://doi. org/10.4102/Pythagoras. v39i1.377

Papert, S. 1972. Teaching children to be mathematicians vs. Teaching about mathematics. *The International of Mathematical Education in Science and Technology*. 3 (3): 249-262.

Parveen, H. & Showkat, N. 2017. Content Analysis. Media & Communication Studies: Pathshala.

Polit, D. F. & Beck, C.T. 2014. Essentials of Nursing Research: Appraising evidence for nursing Practice. Eighth edition. Philadelphia, Pa: Wolters Kluwer/Lippincott Williams & wilkins.

Ramrathan, Labby., Le Grange, Lesley. & Shawa, Brian. 2017. In Ramrathsn, Labby, Le Grange, Lesley & P. (eds.). *Education studies for initial teacher development.* Lansdowne: juta. Pp.456-469 (ISBN: 978-1-48510-266-3).

Reid, K., Flowers, P & Larkin, M. 2005. Exploring Lived Experience. The Psycologist, (18)1, January: 20-23.

Republic of Namibia. 2008. *Strategic Plan*. Windhoek: Ministry of Education, Arts and Culture.

Robinson, M. 2009. Practitioner inquiry in South African Schools: What, how and why (not). Educational Action Research, 17(1): 121-131.

Rohler, D. & Taylor K. 2007. The shuffling of mathematics problems improves learning. A Journal Of The Association For Psychological Science, (35):481-498.

Rohrer, D. & Pashler H. 2007. Increasing Retention Without Increasing Study time. Association for Psychological Science 4(16): 183-186.

Rohrer, D. & Pashler H. 2007. Increasing Retention Without Increasing Study time. Association for Psychological Science 4(16): 183-186.

Rohrer, D. & Pashler H. 2007. Increasing Retention Without Increasing Study time. Association for Psychological Science 4(16): 183-186.

Rohrer, D. 2012.Interleaving helps students distinguish among similar concepts. *Educational Psychology Review*, 24:355-367.

Rohrer, D., & Taylor, K. 2006. The effects of overlearning and distributed practice on the retention of mathematics knowledge. *Applied Cognitive Psychology*, 2- (9), December:1 209-1 224.

Sahar, F.2016. Quantitative Research Methods: How to write objectives of research? [Online] Available:https//www.slideshare.net

Schroeder, T. L. & F. K. 1989. Developing understanding in mathematics via problem solving. In P.R. Trafton & A.P. Schulte (eds). New directions in elementary school mathematics. Reston, VA: NCTM,31-42.

Scoenfeld, A.H. 1985. *Mathematics problem solving*. London: Academic Press.

Scoenfeld, A.H. 1987. *Cognitive science and mathematics education*. Hillsdale: Lawrence Erlbaum.

Seidman, I. 2013. *Interviewing as qualitative research: A guide for researchers in education and the social sciences.* 4th ed. New York: Teachers College Press.

Sekeres, M., Moscovitch, M. & Winocur, G. 2018. *Mechanisms of Memory consolidation and Transformation*. Toronto: Rotman Research Institute. Available: https://www.researchgate.net/publication/313542134

Semb, G.B. & Ellis, J. A. 1994. Knowledge Taught in School: What is remembered? Review of Educational Research, 64 (2), Sumer:253-286.

Serin, H.2018. A comparison of Learner-Centred and Teacher-Centred Approaches in Educational settings. *International Journal of Social Sciences and Educational studies*, 5(1, September:164-167).

Simon, M.A. & Schifter, D. 1993. Towards a constructivist perspective: The impact of a mathematics teacher in-service programme on students. *Education studies in Mathematics*. 25:330-340.

Slimp, M. (Ed.).2014. *Trends in distance education-What college leaders should consider*. A white paper from the Instructional Technology Council, November.

Stacy, K.2005. The place of problem solving in contemporary mathematics curriculum documents. *Journal of Mathematics Behavior*. 24:340-350.

Steinkie, I. 2004. Quality criteria in qualitative research. In U. Flick, E. von Kardoff & I. Steinke (eds.). A companion to qualitative research. London: Sage, 184-190.

Steven, R., Murray, D. A., & Brian E. U. 2003. Massed versus Distribution Practice: Which is Better?. CAPHERD Journal, 28 (1): 19-22.

Stigler, J.W. & Heibert, J. 1998. Teaching is a cultural activity. *American Educator*, 22(4):4-11.

Strauss, A., & Corbin, J. 2008. Basics of qualitative research: Grounded theory procedures and techniques. (3rd ed.). Newbury Park, CA: Sage.

Tembo, A.C.2016. Phenomenological Inquiry as a Methodology for Investigating the Lived Experience of Being Critical Ill in Intensive Care. *Journal of Intensive and Critical Care*, (2) 1:8.

The National I institute for Educational Development (NIED). 2008. The National Mathematics Subject policy Guide Grades 5-15. [Electronic]. Available: http//www.nied.edu.na

The National Mathematics Subject Policy Guide. 2009. Maths Subject Policy Guide. [Electronic]. Available: https//www.nied.edu.na

Tylor, S. J., & Bogdan, R. 1998. Introduction to qualitative research methods: A guidebook and resource. 3rd edition. New York: Wiley.

UMALUSI. 2018. Exemplar Book on Effective Questioning Mathematics. [Electronic]. Available:https://www.umalusi.org.za/docs/reports/2018/Life_Sciences_March%202018.pdf.

Van De Walle, J. A., Karp, K.S. & Bay- Williams, J.M. 2010.Elementary & Middle School Mathematics: Teaching Developmentary. Seventh edition. United States of America: Pearson Education.

Wanjohi, J.M. 2014. Research objectives [Online]. Available : https//www.sps.uobi.ac.ke

Watsson, A. & Mason, J. 1998. *Questions and prompts for mathematical thinking*. Derby: Association of Teachers of Mathematics.

Webb, N.L. 1992. Assessment of students' knowledge of mathematics: Steps towards theory. In D.A. Grouws (ed.). *Handbook of research on mathematics teaching and learning*. New York: Macmillan, 661-709).

What is credibility in qualitative research and how do we establish it? 2017. [Online] Available: https://www.statisticssolutions.com/what-is-credibility-in-qualitative-research-and-how-do-we-establish-it/ [2017, February 21].

Yin, R.K. 1993. *Application of case study research*. Volume 34. London: Sage.

Yin, R.K. 2009. *Case study research: Design & Methods*. Forth edition. Los Angeles, CA: Sage.

Ziebarth, S. W. 2006. Classroom assessment issues related to teaching mathematics through problem solving. In H.L. Schoen & R.I. Charles (eds). *Teaching mathematics through problem solving*. Grades 6-12. Washington: Library of Congress, 3-13.

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Appendix 1:

NOTICE OF APPROVAL

REC: Social, Behavioural and Education Research (SBER) - Initial Application Form

13 August 2019

Project number: 10185

Project Title: Teaching Senior Secondary Mathematics for Retention

Dear Ms MAIYA ANDJAMBA

Co-investigators:

Your response to stipulations submitted on 24 July 2019 was reviewed and approved by the REC: Humanities.

Please note the following for your approved submission:

Ethics approval period:

Protocol approval date (Humanities)	Protocol expiration date (Humanities)
15 July 2019	14 July 2020

GENERAL COMMENTS:

Please take note of the General Investigator Responsibilities attached to this letter. You may commence with your research after complying fully with these guidelines.

If the researcher deviates in any way from the proposal approved by the REC: Humanities, the researcher must notify the REC of these changes.

Please use your SU project number (10185) on any documents or correspondence with the REC concerning your project.

Please note that the REC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

FOR CONTINUATION OF PROJECTS AFTER REC APPROVAL PERIOD

Please note that a progress report should be submitted to the Research Ethics Committee: Humanities before the approval period has expired if a continuation of ethics approval is required. The Committee will then consider the continuation of the project for a further year (if necessary)

Included Documents:

Document Type	File Name	Date	Version
Informed Consent Form	Informed Consent Form	04/05/2019	First
Data collection tool	Interview	06/05/2019	First
Data collection tool	Observation	06/05/2019	First
Default	CV(SU)31May2019_abbreviated	06/05/2019	First
Data collection tool	Questionnaires	06/05/2019	First
Request for permission	Letter to the Director of Education Oshikoto Region	06/05/2019	First
Budget	Research Budget	01/07/2019	Second
Research Protocol/Proposal	Final Research Proposal of Ms. M.N.L. Andjamba	01/07/2019	Second
Parental consent form	Consent_Written-Parent- Legal Guardian	01/07/2019	First
Assent form	Consent_Written-Learners	01/07/2019	First
Proof of permission	Permission Letter from the Director of Education, Arts and Culture, Oshikoto region	24/07/2019	First
Proof of permission	Permission letter from the school principal	24/07/2019	First
Proof of permission	Permission letter from the school principal	24/07/2019	First
Default	RESPONSE LETTER TO THE REC	24/07/2019	Second

If you have any questions or need further help, please contact the REC office at cgraham@sun.ac.za.

Sincerely,

Clarissa Graham

REC Coordinator: Research Ethics Committee: Human Research (Humanities)

National Health Research Ethics Committee (NHREC) registration number: REC-050411-032.
The Research Ethics Committee: Humanities complies with the SA National Health Act No.61 2003 as it pertains to health research. In addition, this committee abides by the ethical norms and principles for research established by the Declaration of Helsinki (2013) and the Department of Health Guidelines for Ethical Research:
Principles Structures and Processes (2nd Ed.) 2015. *Annually a number of projects may be selected randomly for an external audit.*

Investigator Responsibilities

Protection of Human Research Participants

Some of the general responsibilities investigators have when conducting research involving human participants are listed below:

1. Conducting the Research. You are responsible for making sure that the research is conducted according to the REC approved research protocol. You are also responsible for the actions of all your co-investigators and research staff involved with this research. You must also ensure that the research is conducted within the standards of your field of research.

2. Participant Enrollment. You may not recruit or enroll participants prior to the REC approval date or after the expiration date of REC approval. All recruitment materials for any form of media must be approved by the REC prior to their use.

3. Informed Consent. You are responsible for obtaining and documenting effective informed consent using **only** the REC-approved consent documents/process, and for ensuring that no human participants are involved in research prior to obtaining their informed consent. Please give all participants copies of the signed informed consent documents. Keep the originals in your secured research files for at least five (5) years.

4. Continuing Review. The REC must review and approve all REC-approved research proposals at intervals appropriate to the degree of risk but not less than once per year. There is **no grace period.** Prior to the date on which the REC approval of the research expires, **it is your responsibility to submit the progress report in a timely fashion to ensure a lapse in REC approval does not occur.** If REC approval of your research lapses, you must stop new participant enrollment, and contact the REC office immediately.

5. Amendments and Changes. If you wish to amend or change any aspect of your research (such as research design, interventions or procedures, participant population, informed consent document, instruments, surveys or recruiting material), you must submit the amendment to the REC for review using the current
Amendment Form. You **may not initiate** any amendments or changes to your research without first obtaining written REC review and approval. The **only exception** is when it is necessary to

eliminate apparent immediate hazards to participants and the REC should be immediately informed of this necessity.

6. Adverse or Unanticipated Events. Any serious adverse events, participant complaints, and all unanticipated problems that involve risks to participants or others, as well as any research related injuries, occurring at this institution or at other performance sites must be reported to Malene Fouche within **five (5) days** of discovery of the incident. You must also report any instances of serious or continuing problems, or non-compliance with the RECs requirements for protecting human research participants. The only exception to this policy is that the death of a research participant must be reported in accordance with the Stellenbosch University Research Ethics Committee Standard Operating Procedures. All reportable events should be submitted to the REC using the Serious Adverse Event Report Form.

7. Research Record Keeping. You must keep the following research related records, at a minimum, in a secure location for a minimum of five years: the REC approved research proposal and all amendments; All informed consent documents; Recruiting materials; Continuing review reports; Adverse or unanticipated events; and all correspondence from the REC

8. Provision of Counselling or emergency support. When a dedicated counsellor or psychologist provides support to a participant without prior REC review and approval, to the extent permitted by law, such activities will not be recognised as research nor the data used in support of research. Such cases should be indicated in the progress report or final report.

9. Final reports. When you have completed (no further participant enrollment, interactions or interventions) or stopped work on your research, you must submit a Final Report to the REC.

10. On-Site Evaluations, Inspections, or Audits. If you are notified that your research will be reviewed or audited by the sponsor or any other external agency or any internal group, you must inform the REC immediately of the impending audit/evaluation.

Appendix 2:

REPUBLIC OF NAMIBIA

OSHIKOTO REGIONAL COUNCIL
DIRECTORATE OF EDUCATION, ARTS AND CULTURE

Tel (065) 281900
Fax (065) 240315
Enq: Ms H Tende

Private Bag 2028
ONDANGWA
22 July 2019

Ref: 12/3/10/1

Ms Maiya N.L Andjamba
Email.:20907834@sun.ac.za
Cell: 0812223161

Dear Ms Andjamba

RE: PERMISSION LETTER TO CONDUCT RESEARCH IN OSHIKOTO REGION

1. The Office of the Director of Education, Arts and Culture acknowledges receipt of your letter, seeking for approval to conduct a research to investigate the "forgetting problem" in the learning of school Mathematics among secondary school students, you have selected **Etosha SSS** and **Otjikoto SSS** as the study sites.

2. The writing of this letter therefore serves to inform you that permission has been granted to you to conduct the research at the afore mentioned schools on the following conditions:

   - You have to consult the school principals well in advance to ensure a proper co-ordination of other school activities.
   - The research should not interfere with the normal teaching and learning process at the schools.
   - Participation in the research should be on a voluntary basis.

3. We wish that your research study will yield satisfactory results towards the completion of your qualification.

Sincerely Yours

....

MS ALETTA A. EISES
DIRECTOR OF EDUCATION, ARTS AND CULTURE
OSHIKOTO REGION

OSHIKOTO REGIONAL COUNCIL
Director
23 JUL 2019
PRIVATE BAG 2028
ONDANGWA
DIRECTORATE OF EDUCATION, ARTS AND CULTURE

Appendix 3

Etosha Secondary School

Tel.: (067) 221111/2 Fax: (067) 221222 P O Box 7, Tsumeb
e-mail: etoshass@mweb.com.na

24 July 2019

To: Mrs Maiya N.L Andjamba
Email: 20907834
Cell: 0812223161

Dear Ms Andjamba

RE: CONFIRMATION OF PERMISSION GRANTED FOR YOUR RESEACH AT ETOSHA SECONDARY SCHOOL.

This letter serves to officially confirm that Etosha Secondary School does not have any objection to the permission granted by the Director of Education, Arts and Culture, Oshikoto Region, in the letter dated 23 July 2019.

We wish you all the best in your future endeavours.

Yours faithfully

A.T Kaishungu
Principal

MINISTRY OF EDUCATION
ETOSHA SECONDARY SCHOOL
2019 -07- 24
P.O.BOX 7 [illegible]
OSHIKO[illegible]

OTJIKOTO SENIOR SECONDARY SCHOOL

PRIVATE BAG 2003, TSUMEB TEL: (067) 220391 FAX: 221559 E-MAIL: otjikoto@iway.na

Reference No. 703
Enquiries: H.H. SHINGO Date: 24TH JULY 2019

MS. MAIJA ANDJAMBA
EMAIL: 20907834@SUN.AC.ZA
CELL: 081 222 3161

Dear Ms. Andjamba

RE: PERMISSION LETTER TO CONDUCT RESEARCH AT OTJIKOTO SENIOR SECONDARY SCHOOL

1. Otjikoto Senior Secondary School acknowledges receipt of your letter, seeking for approval to conduct a research to investigate the "forgetting problem" in the learning of school Mathematics among secondary school students, you have selected, Otjikoto Senior Secondary School as one of your study sites. Furthermore, our school acknowledges receipt of a letter from Oshikoto Education Director, granting you approval to conduct research in Oshikoto Region.

This letter therefore serves to inform you that permission has been granted for you to conduct the research at our school on the following conditions:

- The research should not interfere with the normal teaching and learning process at the school.
- Participation in the research should be on a voluntary basis.

We thank you for choosing Otjikoto Senior Secondary School and wish you success with your studies.

MINISTRY OF EDUCATION
OTJIKOTO SENIOR SEC. SCHOOL
2019 -07- 24
Private Bag 2003 TSUMEB
Tel: 067-220391 Fax: 067-221559
OSHIKOTO REGION

Thanking you,

H.H. SHINGO

PRINCIPAL

Appendix 4:

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY
jou kennisvennoot • your knowledge partner

FACULTY OF EDUCATION
STELLENBOSCH UNIVERSITY
TEACHERS' CONSENT TO PARTICIPATE IN RESEARCH

Teaching senior secondary mathematics for retention

Dear participant,

It would be genuinely appreciated if you could take part in this study conducted by me, Maiya Namutenya Liina Andjamba, Med student in Mathematics Education from the Curriculum Studies Department at Stellenbosch University. You were chosen as a possible partaker in this research study because you are a Senior Secondary Mathematics teacher. I value your experience and expertise in teaching school mathematics at a senior secondary level. Your experience in this regard will aid me as a researcher to acquire the necessary data to accomplish this study's goal.

1. PURPOSE OF THE STUDY

The aim of this study is to explore the problem of 'forgetting' because daily and in the high-stakes examinations learners forget. Thus the goal for this study is to investigate ways teachers are using in helping learners retain mathematics knowledge when writing high-stakes or other types of examinations that have consequences for learners.

2. PROCEDURES

If you participate in this study voluntarily, I would like you to participate in an interview. Completion of questionnaires and classroom observation might be done after should there be a need. An interview would take no longer than halve an hour. During the interview notes will be taken in order to obtain all information necessary for analysis. With your permission, the interview will also be audio-taped for necessary reviews, analysis and transcription. The rationale behind the interview, questionnaires and classroom observation is to gain insight into what Namibian senior secondary mathematics teachers do as a way of helping their learners deal with forgetting.

3. POTENTIAL RISKS AND DISCOMFORTS

Since confidentiality will be highly maintained and questions are not focused on sensitive confidential private information, there will be no discomfort or hazard in association with this study.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

Learners, future student teachers, teachers, schools, policy makers and the country at large are expected to benefit from different retention and revision strategies. The outcomes of the intended study will have implications for collaboration work for educators or teachers in Namibia to work together with fellow teachers or people from the directive offices to design learning materials and work on projects that can help with revision and retention.

5. CONFIDENTIALITY

Confidentiality with regard to any information you share in this study and that can be identified with you will be maintained as much as possible and will only be disclosed with your permission as deserved by law. Pseudonyms and codes will be used for names when you or your school is referred to. In addition, all soft copy information will be stored on a personal computer secured with passwords familiar only to me in order to keep the data protected. All soft and hard copy data will be securely locked up in a securely locked cabinets or a room accessible only by me. Your participation in this research will stay confidential. During thesis writing process, direct quotation may be used but anonymity will prevail for the protection of respondent’s identities. Confidentiality will persist due to the fact that this study is for academic purposes and there are legal procedures in place that will be followed in connection with thesis and journal articles writing based on the data collected. It is legitimate to access or audit your audio-recorded interview if you wish to make any changes to the information you provided during the interview.

6. PARTICIPATION AND WITHDRAWAL

It is a personal choice to participate in this study and you will in no ways be negatively affected or biased if you opt not to participate or withdraw any time from this research study. You may still continue to be in this study even if you choose to opt out answers to any of the questions. Your participation in this study can be terminated by the investigator should circumstances arise which grant doing so.

7. IDENTIFICATION OF THE INVESTIGATORS

Thank you for taking part, should you have any queries or worries about the research, do not hesitate to contact me Ms Maiya Andjamba (Researcher) at 20907834@ sun.ac.za or at cell phone numbers: +264 0812223161/+27(74) 629-3434 or the research supervisor Dr. M.F. Gierdien at faaiz@sun.ac.za or at Telephone number 0218082289.

8. RIGHTS OF RESEARCH SUBJECTS

You may quit your consent at any period and disengage participation without any penalty or consequences of any kind. You are not waiving any legal requirements because of your participation in this study. Should you have any questions regarding your rights as a subject of research, contact Ms Maléne Fouché [mfouche @sun.ac.za; +27218084622] at the division for Research Development, Stellenbosch University.

SIGNITURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

Please sign below as evidence that you are voluntarily participating and were in no way obliged or pressured into participating. Please support in providing an honest reflection of your feelings, experiences and ideas.

The information above was illustrated to me by Maiya Namutenya Liina Andjamba in English. I was given the platform to ask questions and the answers to these questions were provided by her to my satisfaction.

I hereby grant a voluntarily consent to partake in this research study for the interview, questionnaires and class observation. I was presented with a copy of this form.

______________________________ ________________

Name of Participant/Subject's signature **Date**

SIGNITURE OF RESEARCHER/INVESTIGATOR

I hereby declare that I have explained the information provided in this document to _________________________and [her/his] representative_____________________________. [He/she] was motivated and given sufficient time to ask me any questions in connection to the study. The conversations were conducted in English and no translator was used.

________________________________ ________________

Signature of Researcher/Investigator **Date**

Appendix 5:

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jou kennisvennoot • your knowledge partner

FACULTY OF EDUCATION

STELLENBOSCH UNIVERSITY

PARENT/LEGAL GUARDIAN CONSENT FOR CHILD TO PARTICIPATE IN RESEARCH

I would like to invite your child to participate in a research study conducted by me, Maiya Namutenya Liina Andjamba, Med student in Mathematics Education from the Curriculum Studies Department at Stellenbosch University.

1. PURPOSE OF THE STUDY

The aim of this study is to explore the problem of 'forgetting' because daily and in the high-stakes examinations learners forget.

2. WHAT WILL BE ASKED OF MY CHILD?

If you permit your child to take part in the study, the researcher will again approach your child for their agreement to be active participants in this study by allowing access to their assessments and marks. If the child agrees to take part in the study, he/she will be asked to avoid being absent from school and to be in class for the whole duration of every mathematics period for three to four consecutive weeks and to take part in all the normal school activities thereof.

3. POSSIBLE RISKS AND DISCOMFORTS

There are no foreseeable discomforts, risks or inconveniences in association with this study as the research program will in no way interfere will the normal teaching and learning process. The activities and assessments are part of the curriculum and not something developed for the purpose of research. Confidentiality will be highly maintained concerning accessing and analysis of learners' assessment marks as pseudonyms and codes will be used for names.

4. POSSIBLE BENEFITS TO SUBJECTS AND/OR TO SOCIETY

Learners will benefit directly from strategies that produce long-lasting retention of school mathematics. The results for this study will have implications for collaboration work in designing learning materials and working on projects that can help with retention and revision. The society is therefore indirectly expected to benefit from this intervention.

5. PROTECTION OF YOUR AND YOUR CHILD'S INFORMATION, CONFIDENTIALITY, AND IDENTITY

Pseudonyms and codes will be used for names or when a school is referred to for anonymity. Confidentiality with regard to any information that can be identified with the child will be highly maintained. All soft copy information will be stored on a personal computer protected with passwords known only by me in order to keep the data secured. All soft and hard copy data will be securely locked up in a securely locked cabinets or a room accessible only by me. Your child's participation in this research remains confidential. This study is for academic purposes and there are legal procedures in place that will be followed in connection with thesis and journal articles writing based on the collected data. The child is free to opt-out of their information being shared without any consequences.

6. PARTICIPATION AND WITHDRAWAL

You and your child can decide whether to be part of this study or not. If you permit your child to participate in the study, please take note that your child may choose to quit or refuse participation at any stage without any consequence. Participation can be terminated by the researcher should circumstances arise that may grant doing so.

7. PRESEARCHERS' CONTACT INFORMATION

Should you have any queries or worries about the research, do not hesitate to contact me Ms Maiya Andjamba (Researcher) at 20907834@ sun.ac.za or at cell phone numbers: +264 0812223161/+27(74) 629-3434 or the research supervisor Dr. M.F. Gierdien at faaiz@sun.ac.za or at Telephone number 0218082289.

8. RIGHTS OF RESEARCH PARTICIPANTS

Your child may withdraw their consent at any time and quit participation without any penalty or consequences of any kind. You are not giving up any legal requirements because of your participation in the study. Should you have any questions regarding your rights as a subject of research, contact Ms. Maléne Fouché [mfouche @sun.ac.za; +27218084622] at the division for Research Development, Stellenbosch University.

DECLARATION OF CONCENT BY THE PARENT/LEGAL GUARDIAN .

As the parent/legal guardian of the child I confirm that:

- I have read the information above and it is written in a language that I am comfortable with.
- I was given the platform to ask questions and I was satisfied with the answers provided by her.
- All information concerning privacy, confidentiality, and use of the information have been explained.

By signing below, I ____ agrees that the researcher may approach my child to take part in the study, as conducted by Maiya Namutenya Liina Andjamba.

______________________________ ________________

Signature of Parent/Legal guardian **Date**

DECLARATION OF THE PRINCIPAL INVESTIGATOR/RESEARCHER

I hereby declare that I have explained the information provided in this document to the parent/legal guardian. I also declare that the parent/legal guardian was encouraged and given sufficient time to ask any questions.

____________________________________ __________________

Signature of Researcher/Investigator **Date**

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jou kennisvennoot · your knowledge partner

FACULTY OF EDUCATION
STELLENBOSCH UNIVERSITY
LEARNERS' CONSENT TO PARTICIPATE IN RESEARCH

Teaching senior secondary mathematics for retention

Dear Learner,

Please take time to read the information presented below, which will describe the details of this project and contact me should you desire a further explanation of any part of the project. Furthermore, your participation is entirely voluntary and you are at liberty to decline to take part. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

It would be highly appreciated if you could take part in this study conducted by me, Maiya Namutenya Liina Andjamba, Med student in Mathematics Education from the Curriculum Studies Department at Stellenbosch University. I wish to be present during your mathematics periods, to access your assessments and your assessment marks for the purpose of research. If you permit me, you then become active participants in my research study. You were chosen as possible participants in this project because you are Senior Secondary learners, with Mathematics as one of your school subjects. I value your participation in school mathematics at a senior secondary level. Your participation in this regard will help me to obtain the necessary data being sought to accomplish the goal for this study. The goal of this study is to explore the 'forgetting' problem. The researcher therefore seeks to find ways on how learners can benefit from strategies that produce long-lasting retention for school mathematics, because daily and in the high-stakes examinations learners forget. If you agree to take part in the study you will be required to avoid being absent from school and to be in class for the whole duration of every mathematics period for three-four consecutive weeks and to take part in all the normal school activities thereof.

If you agree to take part in the study, please note that your normal learning program will not be interfered with in any manner. Hence there are no foreseeable discomforts, risks or inconveniences in association with this study. The activities and assessments are part of the curriculum and not something developed for the purpose of research. Confidentiality will be highly maintained concerning accessing and analysis of your assessment marks as pseudonyms and codes will be used for names. You are expected to benefit directly from strategies that will help you deal with the problem of forgetting. The results for this study will have implications for teachers' collaboration work in designing learning materials and working on projects that can help learners with retention and revision.

Codes and pseudonyms will be used for names or when a school is referred to for anonymity. Confidentiality with regard to any information that can be identified with you will be highly maintained. All soft copy information will be stored on a personal computer protected with passwords known only by me in order to keep the data secured. All soft and hard copy data will be securely locked up in a securely locked cabinet or a room accessible only by me. Your participation in this research remains confidential. This study is for academic purposes and there are legal procedures in place that will be followed in connection with thesis and journal articles writing based on the collected data. You are free to opt-out of your information being shared without any consequences, your participation is voluntary. You can decide whether to be part of this study or not. If you participate in the study, please take note that you may choose to quit or refuse participation at any stage without any penalty. Participation can be terminated by the researcher should circumstances arise that may grant doing so.

Should you have any queries or worries about the research, do not hesitate to contact me Ms. Maiya Andjamba (Researcher) at 20907834@ sun.ac.za or at cell phone numbers: +264 0812223161/+27(74) 629-3434 or the research supervisor Dr. M.F. Gierdien at faaiz@sun.ac.za or at Telephone number 0218082289.

RIGHTS OF RESEARCH PARTICIPANTS:

You may withdraw your consent at any time and quit participation without any penalty or consequences of any kind. You are not giving up any legal requirements because of your participation in the study. Should you have any questions regarding your rights as a subject of research, contact Ms. Maléne Fouché [mfouche @sun.ac.za; +27218084622] at the division for Research Development, Stellenbosch University. You have the right to receive a copy of the information and consent form.

If you are willing to participate in this study please sign the declaration of consent.

DECLARATION BY PARTICIPANT

By signing below, I ____ agree to take part in the study, as conducted by Maiya Namutenya Liina Andjamba.

I confirm that:

- I have read the information pamphlet and it is written in a language that I am fluent and comfortable.
- I was given a chance to ask questions and I was satisfied with the answers provided by the researcher.
- I understand that taking part is voluntary and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised in any way.
- I may be asked to leave the study before it has finished if the researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.
- I am satisfied with explanations regarding all issues concerning privacy, confidentiality, and use of the information.

Signed on:

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Signature of Participant

SIGNITURE OF RESEARCHER/INVESTIGATOR

I hereby declare that I have explained the information provided in this document to ____. [He/she] was motivated and given sufficient time to ask me any questions in connection to the study. The conversations were conducted in English and no translator was used.

____________________________________ __________________

Signature of Researcher/Investigator **Date**

Appendix 6:

INTERVIEW QUESTIONS

Semi-structured interview

Part A (structured questions)

Region: ________________ School: _____________________ Teacher: __________________

Part B (semi-structured questions)

1. What is your total number of years in the teaching industry?

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2. What is your total number of years in teaching mathematics Grade 11 and 12?

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3. What is the highest qualification have you obtained so far? (E.g. Grade 12, Certificate, Diploma, Degree, Honors Degree, Master's degree, PhD degree).

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4. As a senior secondary mathematics teacher, what do you do as a way of helping your learners deal with forgetting? Give examples of strategies you use.

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5. What do you understand about retention and revision strategies?

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6. Would you elaborate more on your answer (to question 5)?

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7. Would you mind if I visit your class to learn from your experience with regards to the different retention and revision strategies?

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Appendix 7:

CLASSROOM OBSERVATIONS **Teacher:……………** **School:…………**
Week:…….

Researcher' Class Observation checklist

RETENTION

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
RETENTION STRATEGIES					
RETENTION (MEMORIZATION) STRATEGIES					
Visualisation					
Mnemonics					
Advance organizers					
Drill-&-Practice					
Rote learning					
REVISION STRATEGIES					
Massed practice					
Overlearning					
Exam-Driven-Teaching					
Distributed practice					
Productive practice:					
Spiral revision					
Deepening Mathematical					

Notes:……………………………………………………………………………………………
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Samples of a classroom conversation

Topic:

TEACHER	LEARNERS

Appendix 8:

QUESTIONNAIRES

Questionnaire 1 (unstructured/open-ended questions)

1. What do you understand about retention and revision strategies?

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2. Are they the same or separate?

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3. Provide examples of retention and revision strategy.

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4. Do you think the use of different retention and revision strategies needs to be encouraged in teaching school mathematics in Namibia? Explain giving examples.

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5. There are a lot of recommended teaching and learning strategies to deal with learners' forgetting in mathematics. Describe the strategies you use, to deal with your learners' forgetting and give reasons why you use the specific ones?

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6. How do you make extra time to use the different retention and revision strategies you mentioned in the above question and/or incorporate them within your working hours?

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7. How do you make sure that a class of learners with different learning styles practice in revision groups in an effective manner? Give a practical example.

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8. How do you encourage your learners to practice in your absence/without supervision? How do you make sure that they do practice?

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9. Practice is very important in mathematics. How do you motivate your learners to develop a culture/habit of practicing on their own (without being asked to do so)? Prompt: How do you select and design practice questions? What do you consider when giving learners 'practice'? Where do you get these practice or revision exercises?

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10. What are the challenges that Namibian teachers face in the process of addressing the “forget problem” of their senior secondary school learners in mathematics?
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11. How do you think the challenges you have stated in question 10 could be addressed?
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Appendix 9:

Questionnaire 2: Semi-structured

Part A: Semi-structured

Mark with a cross [×] next to your most appropriate answer or fill in any other appropriate answer and give a reason/s (elaboration) for your choice.

1. When you want your Grade 11 and 12 students to memorise facts in mathematics which of the following do you use?

A) Diagrams e.g. Venn diagrams & KWL diagrams

B) Mnemonics

C) Lyrics and songs

D) A & B

E) Other…………………………………………………………………………………………

Reason:……………………………………………………………………………………...

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2. After showing your students a method or several ways of solving a particular problem you let your learners practice by

A) Collecting a lot of similar practice problems into one assignment

B) Distributing a lot of similar exercise problems across two or more practice sessions

C) Distributing a variety of exercise problems equally across over two or more practice sets

D) Divide the past learned work through a variety of short exercise and activities

E) Other…………………………………………………………………………………………

Reason:……………………………………………………………………………………...

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3. How often do you give your learners at least one mathematical challenging sum/practice problem (demanding thought) where learners are expected to be accounted to themselves and others for their answers through showing their workings?

A) After a lesson

B) After a topic

C) Once week

D) Once a month

E) Other…………………………………………………………………………………………

Reason:……………………………………………………………………………………...

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4. When you compile practice problems which of these are you most likely to do?

A) You give the exact practice/exercise problems in an order as that of the textbooks

B) You give exercise problems based on a give lesson at a time

C) You include further questions of the previous lessons within practice set of the succeeding lesson

D) You give practice problems after a completion of a topic

E) Other………………………………………………………………………………………….

Reason:……………………………………………………………………………………...

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5. Where do you get challenging practice problems that you give to your learners?

6. On what basis do you choose the mathematically challenging problem?

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Part B (unstructured/open-ended questions).

1. What do you know about effective teaching retention and revision strategies that can improve learners' retention in senior secondary school Mathematics classrooms?
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2. What are and why teach retention strategies in senior secondary school Mathematics?
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3. Are there differences between different retention and revision strategies or are they the same?

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4. What is the relationship between revision and/or retention strategies?

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5. What are ways of studying retention/revision strategies of the teachers?

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Appendix 10:

Questionnaire 3 (unstructured/open-ended question)

Please explain how you would introduce and teach any Grade 11 or 12 mathematics topic of your choice. Illustrate how you would use different retention and revision strategies to the best of your ability to help learners retain the content (for the content to last longer in their memories).

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Appendix 11:

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Mathematics pre-test

Topics. Trigonometry(bearings and trigonometrical ratios)

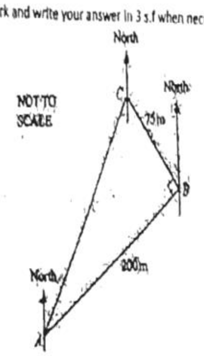
Marks 25

Grade 	Grade 11

Date 	11.09.2019

. Show your work and write your answer in 3 s.f when necessary.

1.



Darlella walks 200m from A to B.

She then turns through 90° and walks 75 m from B to C

(a) Calculate

(i) the distance AC,

Answer(a)(i).....................[2]

(ii) angle CAB.

Answer(a)(ii).....................[2]

(b) The bearing of B from A is 065°.

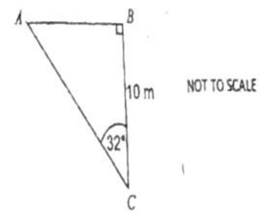
Find the bearing of

(i) C from A 	Answer(b)(i).....................[1]

(ii) A from C 	Answer(b)(ii).....................[1]

(iii) C from B 	Answer(b)(iii).....................[1]

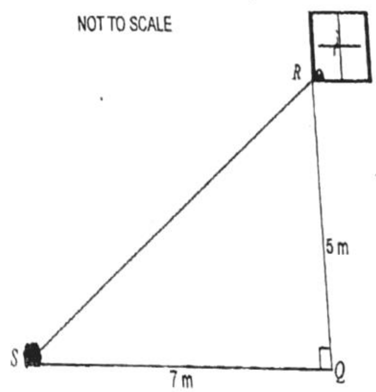
2. Use the triangle drawn below, calculate the length of AC.



Answer.....................[3]

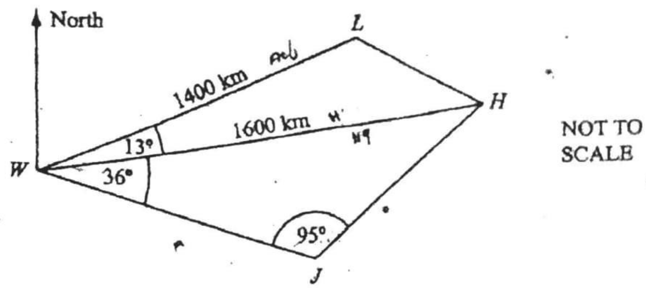
3. Robert is looking at a stone,S, on the ground from an upstairs window at R.

Calculate the angle of depression of the stone from Robert.



Answer.....................[2]

4.



The diagram shows the positions of four cities in Africa, Windhoek (W), Johannesburg(J), Harare(H) and Lusaka(L).

WL=1400km and WH= 1600km.

Angle LWH=13,angle WHJ=36 and WJH=95.

(a) Calculate the distance LH.

Answer(a):............................[4]

(b) Calculate the distance WJ.

Answer(b)............................[4]

(c) Calculate the area of quadrilateral WJHL.

Answer(c)............................[3]

(d) On the map the distance between Windhoek and Harare is 8cm.
Calculate the scale of the map in the form 1:n.

Answer(d)............................[2]

Mathematics post-test

Topic: Trigonometry

Name……………………………………………………………

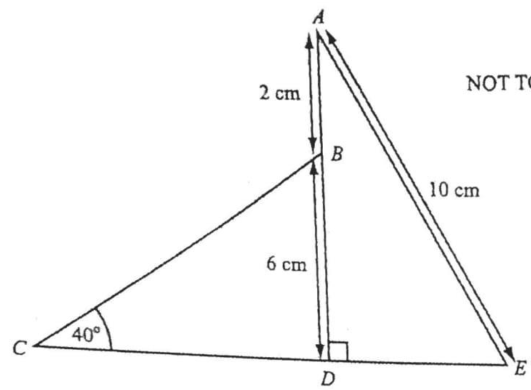
Grade 11

Date 27.09.2019

Instructions

- *Show all your work*
- *Write your answer in 3 s.f when possible*

1.



On the above diagram, $AB = 2\,\text{cm}$, $BD = 6\,\text{cm}$, $AE = 10\,\text{cm}$, angle $BCD = 40°$ and angle $BDE = 90°$.

(a) Write down the length of AD.

Answer(a) AD = ... cm [1]

(b) **Calculate** the length of DE.

Answer(b) DE = ... cm [2]

(c) **Calculate** the size of angle AED.

Answer(c) angle AED = ... [2]

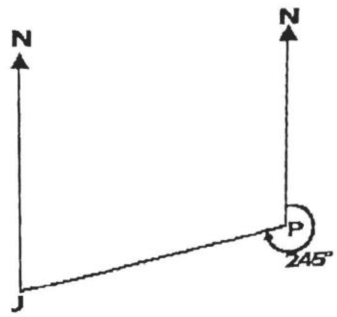
(d) **Calculate** the length of CD.

Answer(d) CD = ... cm [3]

(e) **Find the length** of CE.

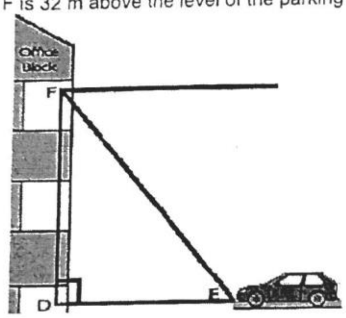
Answer(e) CE = ... cm [1]

2. (a) Peter and John walk towards each other. Peter walks on a bearing of 245°. Find the bearing on which John walks.



[1]

(b) From F, a man can look through his office window and see his car parked in the parking area below. Give that F is 32 m above the level of the parking area and DE equals 78 m.

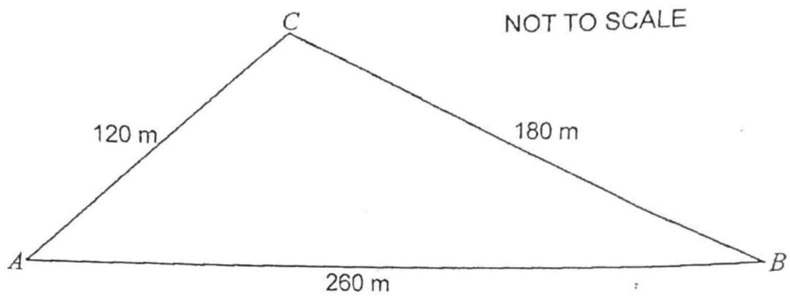


Calculate the angle of depression of the man's car in the car park.

[3]

A

3. The boundary of a park is in the shape of a triangle, ABC as shown below. AB = 260m, BC = 180m and AC = 120m.



Use trigonometry only to solve questions in part **(b)**. You should show your working and should NOT use any measurements from your constructions in part **(a)**.

(b) **(i)** Show clearly that angle ACB is 118.8° correct to 1 decimal place.

Answer **(b)** **(i)**

[4]

(ii) Calculate the area of the park.

Answer **(b)** **(ii)** .... m^2 [2]

(iii) Calculate angle BAC.

Answer **(b)** **(iii)** .... ° [3]

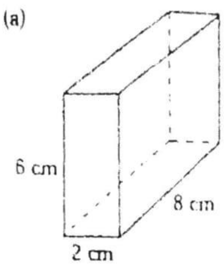
Mathematics

Grade 11

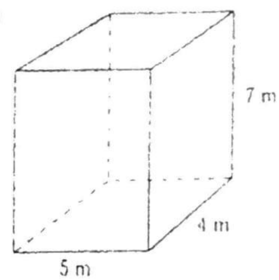
Delayed test

1. Calculate the *volume* and *surface area* of each of the following cuboids.

(a)

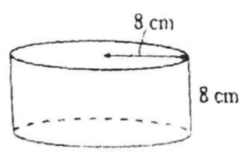


(b)

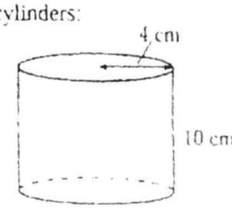


2. Giving your answers correct to 3 significant figures, calculate the *volume* and *total surface area* of each of the following cylinders:

(a)

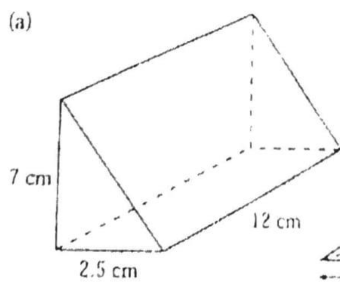


(b)

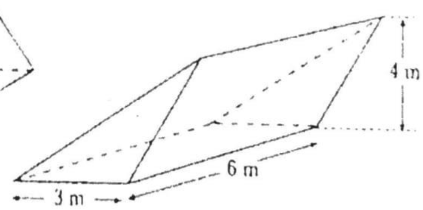


3. Calculate the *volume* of each of the following prisms:

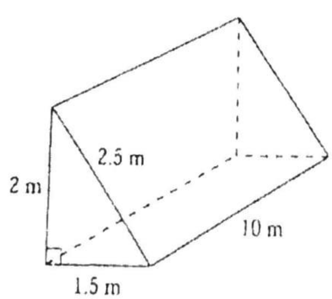
(a)



(b)



4. Calculate the *volume* and *surface area* of the following prism.

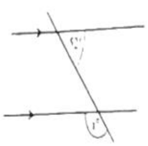


Mathematics Pre-test

Grade 12 Marks ____ / 20

Date ______________

1



NOT TO SCALE

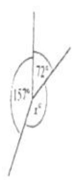
In the diagram, a straight line intersects two parallel lines.

Find the value of x.

Answer x = ... [1]

2

(a) (i)

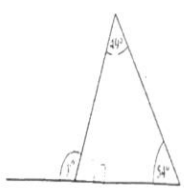


NOT TO SCALE

Work out the value of x.

Answer(c)(i) x = ... [1]

(ii)



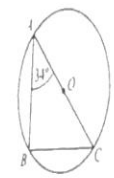
NOT TO SCALE

Work out the value of y.

Answer(c)(ii) y = ... [2]

Geometrical terms and Angle properties

(b)



NOT TO SCALE

AC is a diameter of the circle, centre O.

Calculate angle ACB.

Answer(d) Angle ACB = ... [2]

(c) The diagram below shows parts of shape P and shape Q.
Shape P is a regular hexagon and shape Q is another regular polygon.
The two shapes have one side in common.

NOT TO SCALE

Find the number of sides in shape Q.
Show each step of your working.

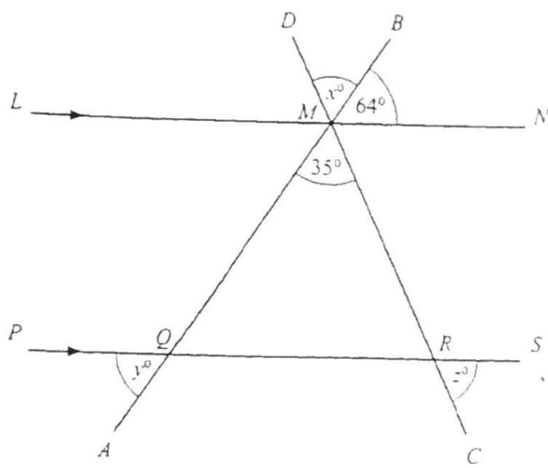
Answer(e) .... [5]

'25618808'

For Examiner's Use

3 (a)

In the diagram below, AB and CD are straight lines which intersect at M.
LMN and $PQRS$ are parallel straight lines.
Angle $QMR = 35°$ and angle $BMN = 64°$.



NOT TO SCALE

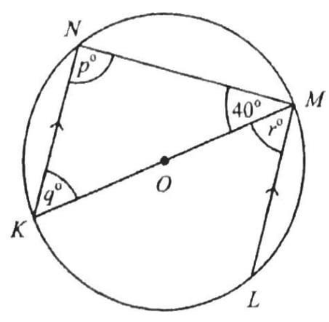
Find the values of x, y and z.

Answer(b) x = ... [1]

y = ... [2]

z = ... [2]

(b)



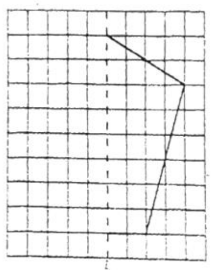
NOT TO SCALE

In the diagram above, the points K, L, M and N lie on the circle centre O.
KN is parallel to LM.
Find the values of p, q and r.

Answer(b) p = ..., q = ..., r = ... [3]

MATHEMATICS POST-TEST GRADE 12 TERM 2 MARKS: 20 27/09/2019

1. In the diagram the line is a line of symmetry for the partly drawn polygon.

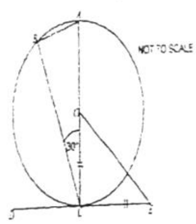


a) Complete the diagram for the partly drawn polygon in the line L1. [2]

b) What is the special name of the complete drawn polygon? [2]

c) Calculate the size of the exterior angle of a regular octagon. [2]

2. The diagram shows a circle, centre *O*, with a diameter *AC*. Angle *ACE* is 30° and *OC* = *CE*.



a) Calculate angle

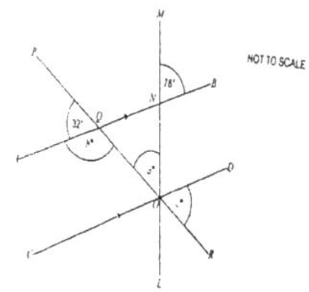
i. Angle *ABC*. [1]

ii. Angle *BAC*. [2]

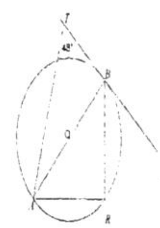
iii. Angle *CEO*. [2]

b) Write down the special name for triangle *CEO*. [1]

3. AB and CD are two parallel lines. PQR and MNL intersect at O.
Angle AQP = 32° and angle MNB = 78°
Find the values of a, b and c. [3]



4. (a) BT is a tangent to the circle, centre O. AB is a diameter and angle ATB = 48°. R is another point on the circle.



Giving a reason, find the size of angle *TAB*.

(i) Angle *TAB*

(Give reason) [2]

(ii) Write down the size of angle *ARB*. [1]

(b) Find the size of each interior angle of a **regular** 7-sided polygon.
Give your answer to the nearest degree. [2]

Mathematics Test Delayed test Grade 12 Marks: 20

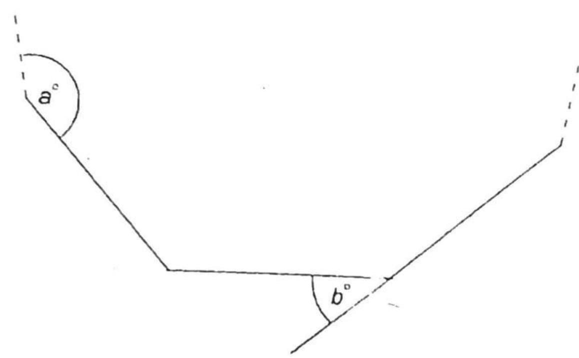
1 **(a)** Factorise completely $3x^2 - 6x$.

Answer **(a)** .... [2]

(b) Find the value of $3x^2 - 6x$ when $x = 3$.

Answer **(b)** .... [1]

2



NOT TO SCALE

The diagram above shows part of a regular nine-sided polygon.
Each interior angle measures a° and each exterior angle measures b°.

Calculate the values of a and b. **Show all your working**.

Answer a = ...

b = ... [4]

3 **(a)** Rajeesh thought of a number.
He multiplied this number by 2.
He then added 10.
The answer was 42.

(i) What was the number Rajeesh first thought of?

Answer(a)(i) .... [1]

(ii) Simon thought of a number x.
He multiplied this number by 3 and then added 8.
Write down an expression in x for his answer.

Answer(a)(ii) .... [2]

(b) Simplify $-8a + 7b - a - 2b$.

Answer(b) .... [2]

(c) Factorise fully $6a - 9a^2$.

Answer(c) .... [2]

(d) Make t the subject of the formula

$$v = u + at.$$

Answer(d) $t =$ .... [2]

(e) Solve the simultaneous equations

$$8x + 2y = 13,$$
$$3x + y = 4.$$

Answer(e) $x =$ .... , $y =$ .... [4]